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Study the Calibration of the High Dose Rate Brachytherapy Radioactive Source ^{60}Co

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Authors' contributions

This work was carried out in collaboration among all authors. TA degined the study and took data from medical institute, performed the mathematical analysis, wrote the protocol, wrote the first draft of the manuscript. PKD managed the analysis and corrected the first drafted paper. SIC managed the paper, guided taking data and SKR managed the literature searcches and corrected references. All authors read and approved the final manuscript.

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ABSTRACT

Aim of this work is to calibrate the high dose rate (HDR) brachytherapy source ^{60}Co. The radioactive source calibration is a very important part of the quality assurance program for dosimetry of brachytherapy source. The goal of this project is the calibration of HDR Brachytherapy source in radiation therapy is the measurement of the air kerma rate which required actual dose to deliver. The source calibration is an essential part of the quality assurance program for dosimetry of brachytherapy source. This research will help the patient who is involving brachytherapy treatment. HDR brachytherapy source ^{60}Co is inserted directly or in close to the tumor. Most commonly using method for calibration of HDR brachytherapy source ^{60}CO is well type ionization chamber. Calibration of the radioactive source ^{60}Co brachytherapy source is very important for the treatment of cancer patient. We have got the variation between RAKR from TPS and measured Air Kerma Rate of ^{60}Co brachytherapy source are 3.2% and 3.04% and which give very good agreement with the Air Kerma Rate (RAKR) is $\pm$5% (from BEBIG protocol, Germany). So, our results were satisfied for brachytherapy treatment. From these results, it must be concluded that, ^{60}Co brachytherapy source is suitable for brachytherapy cancer treatment. It is very difficult to calculate treatment

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deliver dose without calibrating AKR of HDR brachytherapy source. It is very important to verify the calculated Air Kerma Rate by TPS Air Kerma Rate.

Keywords: Brachytherapy; HDR Brachytherapy; ^{60}Co Brachytherapy Radioactive Source; Ionization Chamber; Cancer; Radiation and Radiation Therapy.

2010 Mathematics Subject Classification: 53C25, 83C05, 57N16.

1 INTRODUCTION

Now a day, cancer has become very common diseases to us due our food habit and life style. Cancer is a group of diseases and which it is very common diseases in recent time and which are formed by abnormal cell growth and which has the potential to invade or spread to other parts of the body. There are many types of cancer. The most common types of cancer are lung cancer, prostate cancer, colorectal cancer, stomach cancer, skin cancer, acute lymphoblastic leukaemia, brain tumor, breast cancer and cervical cancer. The risk rate of cancer has enhanced significantly with ages. There are some procedures by which we can give the cancer treatment to the patients and these are: radiation therapy (RT), surgery, chemotherapy and targeted therapy. Brachytherapy is nothing but a radiation therapy which treat cancer by placing radioactive sources inside the patient to kill the cancer cells and to shrink the tumors. It may be temporary or permanent [1]. In temporary brachytherapy, the radioactive sources are placed inside the body with a catheter for a specific amount of time and then removes. And it may be low dose rate (LDR) or high dose rate (HDR). And in permanent brachytherapy, the radioactive sources have injected inside the body permanently. In next section, we will discuss more details about the brachytherapy [1].

For last few decades in the cancer treatment, the HDR brachytherapy has been widely accepted mainly for the treatment of gynecological tumors and for tumors at other sites which are unable to access for LDR techniques [2]. HDR brachytherapy has proven to be a successful treatment for different types of cancer such as prostate, cervix, endometrium, breast, skin, bronchus, esophagus, head and neck and several other types of cancer [3]. For HDR after loading brachytherapy, the most worldwide used isotope is ^{192}Ir. Now a day, the radioactive source ^{60}Co is becoming available with identical geometrical dimensions as miniaturized ^{192}Ir sources and ^{60}Co offers logistical and economic advantages. According to the recommendations of the medical physicist, the clinical use of the brachytherapy radioactive source requires an independent measurement of the air kerma-strength. The calibration of the radioactive sources is needed as the calibration can be made with the use of the in-air measurement technique or with the use of a well type ionization chamber. There is another method is to use a dedicated solid phantom for calibration purposes.

In another technique, it is important to on a fundamental level that ^{137}Cs has low measurement rate sources can also be aligned with any of the strategies. For any case with in-air alignments, the run of the mill signals which is acquired utilizing these sources are low and the last vulnerability in the reference air kerma rate might be pointlessly high [4]. In the case of in-air alignments, the deliberate charge or current is firmly reliant on the estimation separation and blunders out there may yield substantial vulnerabilities in the source adjustment. In order to enhance precision, a few separations ought to be utilized as a part of in-air estimations. In spite of having all the fact that well kind chambers give a simple, quick and solid technique for source adjustment and it must be borne at the top of the priority list that in-air alignment is a more essential strategy. We say that the amount of enthusiasm for all radiation treatment is the assimilated measurement [5].

Numerous doctors swung to herbology, while others grasped homeopathy. There was a re-established enthusiasm for using physical, as opposed to pharmacological, specialists of treatment. Spa-drenching, knead, and sunbathing were re-presented as hydrotherapy and phototherapy. Power and ultra-violet light were utilized as specialists of treatment. Inside periods of its revelation (1895), x-beams were connected to skin illness. They were found to have the ability to annihilate certain dermatologic contaminations, birth absconds, and even malignancies. The impediments of early x-beam tubes, including fluctuating yield and restricted. The disclosure of radium (1898), in any case, presented a reduced wellspring of unvarying exceptionally infiltrating beams, reasonable for outer or inward application.

At first, radium-treatment was in the region of dermatologists and specialists. The component was so uncommon (and costly) that early professionals utilized minor, insufficient amounts. Beginning excitement was supplanted by dissatisfaction. In any case, mass abuse of American (later, African and Canadian) wellsprings of radium mineral brought about the accessibility of adequate amounts of the component for useful application. From that point advance was quick, and by 1920 radium-treatment had dislodged surgery as the favored treatment for gynecologic danger. The previous century has seen emotional advances in surgery and pharmacotherapy; however, the implantation of radioactive sources has likewise developed. Reactor and cyclotron-created radionuclides, with higher particular movement and lower - beam/photon vitality, have extended relevance and patient security. Remote after loading has wiped out radiation introduction to work force. The 21st century is seeing a renaissance of brachytherapy [6]. Brachytherapy is a propelled malignancy treatment. Radioactive seeds or sources are put in or close to the tumor itself, giving a high radiation dosage to the tumor while lessening the radiation introduction in the encompassing sound tissues. The expression "brachy" is Greek for short separation. Brachytherapy is radiation treatment given at a short separation: restricted, exact, and cutting edge [5].

2 BASIC CONCEPT OF RADIATION

Radiation is a kind of energy which comes from a source and which can travel through space and may be capable of penetrate in various materials depending on their energies and types. In broad sense, the radiation may be classified into two categories; one is electromagnetic (EM) and another is particulate radiation. EM radiation can be formed by oscillating electrical and magnetic fields and it has a dual nature i.e. its behave both particle and wave [7]. On the other hand, in radiotherapy there are two types of EM radiations which are mostly used and these two are X-rays and Gamma-rays. We know that the X-rays are the atomic phenomena and we know that X-rays can be produced in the case when a high-speed electron collide with a material with high Z number like Tungsten-Molybdenum in the anode of an X-ray tube on the other hand gamma rays are nuclear phenomena and are produced by intra-nuclear disintegration. And the particulate radiation refers to the energy propagated by moving the corpuscles, which have definite rest mass, definite momentum and defined position at any time [8]. Example of particulate radiation are: electron, proton, neutron etc. The block diagram of radiation classification are shown in Fig. 1.

There are two types of radiation [7]. These are:

i) Non-ionizing radiation.
ii) Ionizing radiation.

i). Non-ionizing radiation: It is a kind of radiation which cannot ionize the matter. We normaly use this radiation in our everyday life and are exposed to non-ionizing radiation sources every day. This kind of radiation does not contain enough energy to ionize atoms or molecules. The example of non-ionizing radiations are coming from this devies: Microwave Ovens, Global Positioning Systems (GPS), Cellular Telephones (Mobile Phones), Television Stations, FM and AM radio. There other ono-ionizing radiation which are in different forms include the earths magnetic field and magnetic field exposure from proximity to transmission lines, household wiring and electrical appliances [9].

ii). Ionizing radiation: It is a kind of radiation which can ionize successful the matter either directly or indirectly. Ionizing radiation are two types [7]: (a) Directly ionizing radiation (b) Indirectly ionizing radiation.

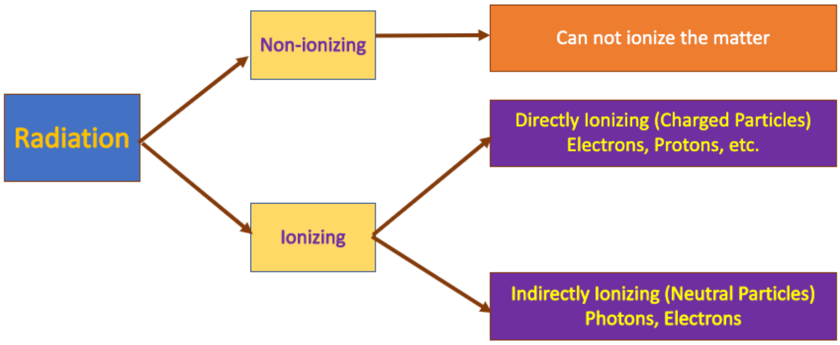

Fig. 1. Block diagram of radiation

(a) Directly Ionizing radiation: In this process, the deposition of energy in the medium go through the direct Coulomb interactions between the directly ionizing charged particle and the orbital electrons of atoms in the medium. Example: electrons, protons etc.
(b) Indirectly Ionizing Radiation: Here, the deposition of energy in the medium goes through in indirectly by two different processes: (1) Step-1: In this step of indirect ionizing radiation, a charged particle like electrons or positrons and neutrons release photons or heavier ions are emitted from the medium (2) And step-2, in the step of indirectly ionizing radiation, the released charged particles deposit energy to the medium by process of the direct Coulomb interactions with orbital electrons of the atoms in the medium.

When these EM rays and particulate radiation interact with medium, there are different phenomena will come into play among them photo-electric effect, Compton effect and pair production are very common and which have some clinical importance in radiation therapy. Among three, Compton effect is the most important in latest megavoltage radiation therapy while photo-electric effect has a primary importance in diagnostic radiology and pair production will come in play when an interaction with the electromagnetic field of the nucleus. The probability of happening this process will become larger with the atomic number and this is possible to happen only when the photon with energy in excess of 1.02 MeV and will go very close to the nucleus of an atom, in this way the photon will disappear and a positron and an electron will appear.

3 BASIC CONCEPT OF RADIATION THERAPY

Cancer treatment with radiation, well known as radiation therapy, is a kind of treatment method in which cancer and tumor can be cured by applying proper doses of radiation using the appropriate radioactive sources. In the case for high measurements, radiation is very useful for slaughtering growth cells and therapist tumors. And for the low measurements, the radiation is useful as a part of x-ray beams to visualized the inside patients body, like the case where x-ray beams of patients teeth or broken bones and which is known as bone x-ray [10].

Radiation treatment is a nearby and easy treatment than other kinds of existing cancer treatments in the world and it is so much different from chemotherapy and in this treatment the drugs course all through the entire body. There are two basic types of radiation treatment in the world: outer radiation treatment and inner radiation treatment. In the case of outer radiation treatment, a light emission is coordinated from outside the body at the malignancy and for the inner radiation treatment a wellspring of radioactivity is surgically set inside the body close to the disease and which well known a brachytherapy [10]. Normally, radiation physicist and radiation oncologists develops a patients treatment plan through a process called treatment planning. In the time of simulation, one need a detailed imaging scans which show the exact location of a patients tumor and the normal areas around it clearly. For these types of imaging, the scans are usually CT scans, but not the MRI, PET scans. CT scans are very important for radiation treatment planning and which is often used in treatment planning for radiation therapy. In the time of CT scanning process, a picture of the inside of the body is created by a computer linked to an x-ray machine using software. CT scans are often used in treatment planning for radiatrion therapy shown in Fig. 2.

It can also be generated from computer simulations. In the time of simulation and daily treatments process, it is very important to ensure that the patient will be in the exactly the same position at every day imaging compare to the machine providing the treatment or doing the imaging of the scan. For some special cases, the body melds, head masks, or other devices are needed to be constructed for an individual patient to make it easier for the patient to stay still and safe. Sometimes, temporary skin marks and even tattoos are used to help with precise patient positioning.

Fig. 2. CT scans are often used in treatment planning for radiation therapy [11]

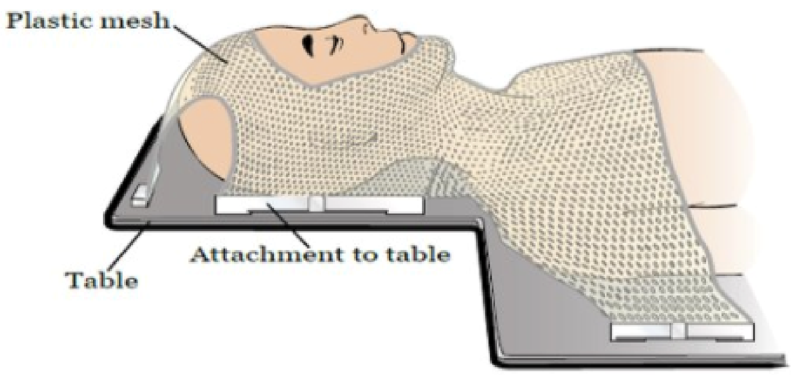

Fig. 3. Radiation Therapy Head Mask [12]

For some individual patients who are getting radiation to the head may need a head mask. This mask will help to keep the head from moving so that the patient should stay in the exact the same position for each treatment. After doing the simulation, the radiation technologist may then determine the exact area that will be treated for that patient, and estimate the total radiation dose that will be delivered to the tumor, this treatment planning will help the radiation technologist or doctors to know that how much dose will be allowed for the normal tissues around the tumor, and the safest angles (paths) for radiation delivery [11] Fig. 3 shows the radiation therapy on a head and neck musk.

3.1 How Radiation Therapy Works against Cancer

The radiation with higher doses in the time of radiation therapy either kill the cancer cells or slows down the cancers growth by damaging their Deoxyribonucleic Acid (DNA). And the exact method of cell damage with the help of nuclear radiation is still an important area of active research topics. These damaged or destroyed DNA have gone beyond repair and it will stop diving or it will go for die. All the damaged and destroyed cells are broken down and they are removed from the body by damaging the cells with the help of the radiation. This type of radiation therapy cannot kill the cancer cells directly. Normally, this radiation therapy takes few days or sometimes few weeks of treatment before damaging enough DNA of cancer cells to die. After giving successive radiation therapy to the cancer cells, it will keep dying for week to months due to the complete the radiation therapy.

In the time of radiation therapy, the triumph of removing or getting rid of tumor depends on the radio sensitivity of tumor and also depend on the neighboring normal tissue tolerance (NTT). We can be defined the Tumor Lethal Dose (TLD) as the dose of the nuclear radiation which produces the complete and permanent regression of tumor in vivo in zone irradiated. There is another term Therapeutic Index (TI) and which can be determined by taking the ratio of NTT/TLD and it explains whether a particular disease can be treated or not. There is another important term in radiation therapy and which is radio-sensitivity and it can be expressed the response of the tumor to irradiation and is larger for highly mitotic, undifferentiated cells like malignant cells. One of the properties of malignancy cells is that they can develop and separate quicker than ordinary cells in general. This property makes them especially helpless against radiation.

Additionally, radiation can harm the typical cells, but since the ordinary cells are developing more gradually and they are better to repair radiation effect than the growth cells in tumors. In the case of a specific end of the goal is to give ordinary cells more time to mend and lessen reactions, radiation medicines which are regularly given in little measurements over several weeks duration [4].

3.2 Types of Radiation Therapy

There are two main types of radiation therapy which are commonly used in cancer treatment in the world and these are: (i) External beam radiation therapy (ii)Internal beam radiation therapy.

3.2.1 External beam radiation therapy

The radiation therapy is said to be as external beam radiation therapy if the beam nuclear radiation of the radiation therapy comes from a far distance outside the patients body by not touching the patients body, but which can be move round the patients body in 360-degree angle. It can send the radiation to just a single part of the patients body from many directions by ensuring not to affected the healthy tissues. It is known as a local treatment that is, it treats a specific part of the patients body.

3.2.2 Internal Radiation Therapy

It is another type of radiation therapy of cancer treatment in which we can see a wellspring of radiation has injected into the patients body and the radiation source can be strong but short half-life. This type of radiation treatment with strong radioactive source is known well as brachytherapy. In this type of radiation treatment,

the essentials tools are seeds, strips, or cases that contain a radiation source and which are put inside the patients body particularly inside the tumor or very close to the tumor. Because of having some similarity between the outside radiation treatment with brachytherapy, both are known as neighborhood treatment and treats just a particular piece of your body. From the among radiation therapy types, which one will apply may depend on many factors, including:
a) The type of the cancer.
b) The size of the tumor.
c) The location of the tumor in the body
d) How close the tumor is to normal tissues that are sensitive to radiation therapy?
e) History of the patients general health and medical condition and treatment.
f) Whether patients will have other types of cancer treatment or not.
g) Patients age and other medical condition are also important factors.

3.3 Brachytherapy

Brachytherapy is nothing but a radiation therapy of one kind and in this type of radiation therapy a fixed radiation source is needed to be inserted into the patients body or beside the area requiring treatment. Basically, brachytherapy is used for the treatment of cervical, prostate, bosom, and skin disease and can also be used for treating the tumors in numerous other body sites. In Brachytherapy, the treatment has exhibited that the growth cell cure rates of brachytherapy are either tantamount to surgery and outer pillar radiotherapy (EBRT. This brachytherapy can be utilized for different treatments, for example, surgery, EBRT and chemotherapy. Brachytherapy are two types:
(i) High dose rate brachytherapy
(ii) Low dose rate brachytherapy.

3.3.1 High-dose rate (HDR) brachytherapy

HDR brachytherapy is a type of internal radiotherapy which implies every treatment session is brief and this treatment process doesn't require that patient be admitted to the healing facility. In this treatment method, a radioactive material is put in the patients body for a brief period from a couple of minutes up to 20 minutes in HDR brachytherapy and here patient may experience maybe a couple sessions daily finished various days or weeks [13].

3.3.2 Low-dose rate (LDR) brachytherapy

LDR brachytherapy is type of radiotherapy in which the radioactive materials are needed to be injected directly inside the patients body, in or nearby a tumor, for a specific amount of time and then withdrawn depending on the treatment planning according to the medical physicist [14]. In this radiotherapy system, the patient is treated by a low dose of radiation. It gadgets might be situated amid surgery that may require anesthesia or sedation to enable patient to stay as yet amid the technique and to lessen inconvenience.

3.4 List of Radiation Sources Used in Radiotherapy

Commonly used radiation sources (radionuclides) for brachytherapy [8].

4 CALIBRATIONS TECHNIQUES

There four different techniques for calibration of the Brachytherapy. These are: (A) In-air measurement technique (B) Ionization chambers to be used (C) Calibration using well type chambers (D) Calibration using solid phantoms.

4.1 In-air Measurement Technique

In this calibration technique known as In-air measurement technique, we need a strategy for adjusting a 'high-vitality' photon source utilizing an in-air alignment system [15]. This technique is not very useful for ^{125}I or ^{103}Pd because of their being discharged a low vitality of the photons from these radioactive sources. In this calibration technique, the air mugginess may influence the weakening of the low vitality photons; therefore, influencing the deliberate current more than

Table 1. Specification of all solid angle Ge spectrometer

Radionuclide	Type	Half-life	Energy
^{131}Cs	EC, e^-	9.7 days	30.4 keV
^{137}Cs	β-particles, γ-rays	30.17 years	0.512, 662 MeV γ
^{60}Co	β-particles, γ-rays	5.26 years	1.17, 1.33 MeV γ
^{192}Ir	γ-rays	73.8 days	0.38 MeV
^{125}I	EC, ϵ	59.6 days	27.4, 31.4 and 35.5 keV
^{103}Pd	EC, ϵ	17.0 days	21.0 keV (mean)
^{106}Ru	β-particles	1.02 years	3.54 MeV

estimations with ^{192}Ir brachytherapy radioactive sources. In the present part of this technique, the in-air adjustment strategies, rectification factors are given for the alignment of ^{192}Ir HDR sources [15]. In spite of having the redress factors in just minor vitality reliance, it can in this manner be utilized, without loss of exactness, in alignment of ^{60}Co and ^{137}Cs brachytherapy sources.

4.2 Calibration Using Well Type Ionization Chambers

This type of calibration method contains a well type ionization chamber for brachytherapy radioactive source. It is particularly used for radiotherapy applications and ideally equipped for estimating the reference air kerma rate of both LDR and HDR radioactive sources. One should take note that if the chamber is fixed and the weight of the gas is at a more elevated amount than the encompassing barometrical weight, which might be build up an issue of moderate spillage of the gas. For this kind of situation, an adjustment is required in the alignment factor. In this technique, some chambers are open to the air require remedy for temperature and weight as we know that the alignment factor depends on a thickness of air relating to standard encompassing conditions, generally 20C or 22C and 101.3 KPa. In this technique, we need a thick divider for the pressurization may retain a huge piece of the radiation to be estimated. By using a remarkably characterized embed for reproducible situating of such a source one can check the chamber flag and an elective strategy for checking the chamber's strength is to light it in an outside ^{60}Co bar under reproducible conditions. Fig. 4 shows the BDS 1000 well-type ionization chamber with the standard imaging MAX 4000 electrometer.

Fig. 4. BDS 1000 well-type ionization chamber with the standard imaging MAX 4000 electrometer [16]

In this calibration process, the well type chambers provide a getable and reliable method for calibrating brachytherapy radioactive sources. There is a point called calibration point which is defined as the point at which the Centre of the source is positioned during the calibration period and this point may vary from one source to another depending on the source length. In some ionization chambers for this technique, one can have a fixed, non-removable, spacer in the well and the source is then conveniently placed on the top of the spacer.

4.3 Calibration Using Solid Phantoms

This is a type of calibration technique where the solid phantom is used as a tool in the radioactive source calibration and which has two different aspects. In the case when the calibration radioactive source has calibrated by using in-air measurements techniques or a well type ionization chamber technique, then that solid phantom might be used as a QC tool to check the calibration. In this technique, a measurement is made in a solid phantom and the ratio, q=MC/MP.

Where MC represents the measurement of in the time of the calibration and MP represents the measurement of charged in phantom. There is an advantage of using phantom and which is the reproducibility in the distance and that is why the in-phantom measurement provide a method for monitoring the quality of the source calibration. If there is a large deviation from the predicted q-value is measured in the time of calibration, then it is indicative of an erroneous calibration procedure and the whole procedure should carefully be analyzed and reviewed. The special care should be taken for the measurement distance if phantom is made of slabs for keeping constant value from one source calibration to another.

4.4 Relative Measurement

There is one more type of calibration technique and which is the relative measurement. Sometimes while taking measurement, it is impractical to check of the source quality as far as the total amounts. In spite of having the fact that this condition is exceptionally unwanted, the physicist should endeavor to build up a confirmation framework with the locally accessible means. There is a fundamental issue and which is to have a steady set-up to stay away from any vulnerability caused by variety in separation or situating of the source. Readings can be contrasted and the source quality incentive from the testament after amendment for source rots between the date of the declaration and the estimating date.

5 CHARACTERISTICS OF HIGH ENERGY PHOTON EMITTING BRACHYTHERAPY SOURCE

^{60}Co source: The half-life of the radioactive source ^{60}Co is 5.27 yar and this radioactive source is utilized as HDR brachytherapy. The radioactive source ^{60}Co experiences γ-decay to energize conditions of ^{60}Ni (99. 88%). It will go to the ground state by de-exciting means of for the most part emanation of -beams of 1.173 and 1.332 MeV, each with an outright force of almost 100%. The principle γ-rays produced vitality in the middle of 0.318 and 1.48 MeV. The ^{60}Co delivered through neutron catch by ^{59}Co. A pure photon source happened from low vitality electron produced by ^{60}Co. It is effectively consumed by the cobalt materials or exemplification layers days [17]. The gamma scheme of the radioactive source ^{60}Co is shown in Fig. 5 [18].

$$^{59}_{27}Co +^{1}_{0} n \rightarrow ^{60}_{27}Co +^{0}_{+1} \beta \tag{5.1}$$

$$^{60}_{27}Co +^{0}_{+} \beta \rightarrow ^{60}_{28}Ni +^{0}_{-1} e + \bar{\nu} + \gamma \tag{5.2}$$

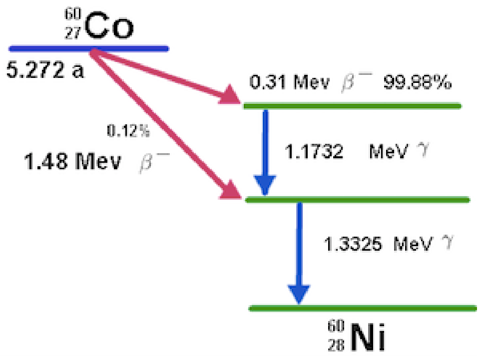

Fig. 5. ^{60}Co decay scheme [18]

6 MATERIALS AND METHOD

For our measurements, we have used ^{60}Co radioactive source for the calibration of HDR brachytherapy radioactive source. Among four different techniques of calibration, we have use the calibration of well type ionization chamber. For that measurements, we some essential materials for successfully complete the study. The materials we need for our work: (1) ^{60}Co radioactive source (2) Well type ionization Chamber (3) Source guide tube (4) Electrometer (5) Special Cable (6) Treatment Planning system, (7) Barometer (8) Applicator and (9) Stopwatch.

6.1 ^{60}Co Source

^{60}Co is a radioactive isotope. The radioactive isotope ^{60}Co is produced by bombardment of neutron to natural target nucleus^{59}Co. This newly formed isotope ^{60}Co decays in ^{60}Ni by emitting β- and γ- rays. Half-life of ^{60}Co is 5.27 years.

We were used this source to calibrate its air kerma rate by using well type ionization chamber technique.

6.2 Well Type Ionization Chamber

We need a set of well type ionization chambers those were used to measure the radiation dose shown in Fig. 2. The machine was calibrated to ensure that it works properly by comparing different measured data. According to AAPM TG-56, the well-type chamber is required for the source strength measurement of radioactive after loading sources. The calibration of the well-type chamber is traceable to NIST, USA and PTB, Germany. The well-type chamber is suitable for the calibration of high dose rate (HDR) and pulsed dose rate (PDR) sources such as 192Ir and ^{60}Co. Calibrations for low dose rate sources (LDR) such as ^{137}Cs are available upon request [19].

(1). Source guide tube.
(2). Electrometer.
(3). Special cable.
(4). Treatment Planning System (TPSs).
(5). Barometer.
(6). Applicator.
(7). Stopwatch.

7 RESULTS AND DISCUSSION

The air kerma rate calibration of cobalt-60 brachytherapy source was performed in Radiotherapy Department at Rajshahi Medical College Hospital, Rajshahi. Calibration data of cobalt-60 source are shown in Table 2, and Table 4. Table 3 and Table 5 are the identification of the point of the source strength verification.

7.1 Data Collection

We have collect our data from Rajshahi Medical College Hospital and are shown in Tables 2-5.

Table 2: To check the source strength verification on date 11/04/2018

Table 2. Source strength verification

Observation	Readings 1(nA)	Readings 2(nA)
1	10.51	10.05
2	10.53	10.56
3	11.12	11.14
4	11.61	11.63
5	12.02	12.04
6	12.35	12.37
7	12.61	12.63
8	12.80	12.82
9	12.94	12.95
10	13.01	13.01
11	13.02	13.03
12	12.98	12.98
13	12.87	12.87
14	12.71	12.71
15	12.48	12.47
16	12.19	12.17
17	11.82	11.80
18	11.36	11.33
19	10.79	10.76
20	10.15	10.10

Table 3: To identify the point of the source strength verification on date 11/04/2018

Table 3. Source strength verification

Observation	Current (nA)		Average Current (nA)
	Readings 1(nA)	Readings 2(nA)	
11	13.02	13.03	13.025

(Source: BEBIG protocol used in Rajshahi Medical College Hospital)

Table 4: To check the source strength verification on date 12/04/2018

Table 4. Source strength verification

Observation	Readings 1(nA)	Readings 2(nA)
1	10.50	10.00
2	10.51	10.55
3	11.10	11.15
4	11.60	11.64
5	12.01	12.05
6	12.30	12.35
7	12.60	12.64
8	12.80	12.84
9	12.92	12.94
10	13.02	13.02
11	13.04	13.05
12	12.95	12.90
13	12.85	12.85
14	12.70	12.70
15	12.45	12.44
16	12.15	12.12
17	11.82	11.80
18	11.35	11.33
19	10.75	10.70
20	10.15	10.10

Table 5: To identify the point of the source strength verification on date 12/04/2018

Table 5. Source strength verification

Maximun postion	Current (nA)		Average Current (nA)
	Readings 1(nA)	Readings 2(nA)	
11	13.04	13.05	13.045

7.2 Mathematical Calculation

For the manually calculation a formula has been used. The formula shown in bellow

$$K_R(\frac{MGy}{h}) = K_p K_s K_r k[\frac{\frac{mGy}{h}}{nA}]\times M[nA] \tag{7.1}$$

Where, $K_R$is the Air Kerma Rate
K_p is Polarization correction factor =1.000
K_s is Ion collection factor=1.007

K_r is the temperature pressure correction factor=1.023 KPa The Calibration factor,
N_k=1.145 $\times 10^6$Gym^2/h/A
Temperature T=20^{0}c
Pressure=101.36KPa
M is the Point of the source strength verification on date 11/04/2018 =13.025
Air Kerma rate
K_R=1.000$\times$1.007$\times$1.023$\times$1.145$\times 10^6 \times$13.025
=15363.4 Gym^2/h

Reference value for air kerma rate from TPS is, Air Kerma Rate, K_R=15854.6 Gym^2/h

$$Variation = \frac{Reference\ Value - Measurement\ Value}{Mesurement\ Value} \times 100\% \tag{7.2}$$

After putting the values, we get = $\frac{15854.6-15363.4}{15363.4}$ $\times 100\%$ =3.2%

AND, M is the Point of the source strength verification on date 11/04/2018 =13.035
Air Kerma Rate, K_R=1.000$\times$1.007$\times$1.023$\times$1.145$\times 10^6 \times$13.045
=15387.03 Gym^2/h

Reference value for air kerma rate from TPS is, Air Kerma Rate, K_R=15854.6 Gym^2/h

$$Variation = \frac{Reference\ Value - Measurement\ Value}{Mesurement\ Value} \times 100\% \tag{7.3}$$

After putting the values, we get = $\frac{15854.6-15387.03}{15387.03}$ $\times 100\%$ =3.04%

Calibration of ^{60}Co brachytherapy source is very important for the treatment of cancer patient. The variation between RAKR from TPS and measured Air Kerma Rate of ^{60}Co brachytherapy source are 3.2% and 3.04%. Reference Air Kerma Rate (RAKR) is $\pm$5% (from BEBIG protocol, Germany). But $\pm$3% (mobile fraction) should be possible (BEBIG protocol, Germany) [4]. So, our results were satisfied for brachytherapy treatment. From these results, it must be concluded that, ^{60}Co brachytherapy source is suitable for brachytherapy cancer treatment.

8 CONCLUSIONS

The Brachytherapy is most commonly used cancer treatment. Different radiation sources are used in Brachytherapy treatment. In this project ^{60}Co is used as a radiation source. Air Kerma Rate is a unit which is used to indicate how much dose should be I implement for a cancer patient. It has great importance to identify the variation of dose rate of ^{60}Co from beginning to present. The Air Kerma Rate Calibrations are using an independent manual procedure. It is very difficult to calculate treatment deliver dose without calibrating AKR of HDR brachytherapy source. It is very important to verify the calculated Air Kerma Rate by TPS Air Kerma Rate.

The Air Kerma Rate of ^{60}Co HDR brachytherapy source is $\pm$5% and $\pm$3% (BEBIG Protocol, Germany) [20]. So, it must be required to calculate the air kerma rate of ^{60}Co brachytherapy source for the treatment of cancerous patient.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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