ACCEPTANCE TESTING, CALIBRATION AND DECOMMISSIONING OF RADIOTHERAPHY EQUIPMENT

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ABSTRACT

Radiotherapy therapy is a form of treatment for cancer that employs high-energy beams to destroy cancer cells. Radiation treatment is most generally utilized with X-rays; however, protons or other radiation types can also be used. The most typical radiation therapy for the treatment of cancer is external beam radiation therapy. A machine that transmits a radiation beam through the skin to a targeted area of the body, commonly a tumor. Therefore, in order for a radiotherapy machine to fully functional and safe to use, some acceptance testing should be done by the manufacturer and medical physicist. This review discussed the a) safety checks, b) mechanical checks, and c) dosimetry measurement to be done in order to ensure the radiotherapy equipment are operating in a manner suited to real-world circumstances and usage. The calibration of the X-ray machines is essential to maintain precision consistency for measuring machines by referring to the reference calibrating apparatus and then adjusting as appropriate. The key benefit of calibration is that it preserves measurement precision, consistency and repetition providing reliable standards and results. WHO has released a number of technical publications on the evaluation, selection, and management of healthcare technology; however, there is currently no guidelines on decommissioning medical devices and no systematic review of the implications of decommissioning on the economy, the environment, and people's health until now. The elimination of inequalities in access to medical devices presents a difficult problem since it calls for an analysis of the regulatory, technological, management, and procurement structures in place.

ABSTRAK

Terapi radioterapi adalah satu bentuk rawatan untuk kanser yang menggunakan pancaran tenaga tinggi untuk memusnahkan sel-sel kanser. Rawatan sinaran biasanya digunakan dengan sinar-X, namun proton atau jenis sinaran lain juga boleh digunakan. Terapi sinaran yang paling tipikal untuk rawatan kanser ialah terapi sinaran pancaran luaran. Mesin yang menghantar pancaran sinaran melalui kulit ke kawasan sasaran badan, biasanya tumor. Oleh itu, untuk membolehkan mesin radioterapi berfungsi sepenuhnya dan selamat digunakan, beberapa ujian penerimaan harus dilakukan oleh pengilang dan ahli fizik perubatan. Semakan ini membincangkan a) pemeriksaan keselamatan, b) pemeriksaan mekanikal, dan c) pengukuran dosimetri yang perlu dilakukan untuk memastikan peralatan radioterapi beroperasi dalam cara yang sesuai dengan keadaan dan penggunaan dunia sebenar. Penentukuran mesin X-ray adalah penting untuk mengekalkan ketekalan ketekalan bagi mesin pengukur dengan merujuk kepada radas penentukuran rujukan dan kemudian melaraskan mengikut kesesuaian. Faedah utama penentukuran ialah ia mengekalkan ketepatan pengukuran, ketekalan dan pengulangan memberikan piawaian dan keputusan yang boleh dipercayai. WHO telah mengeluarkan beberapa penerbitan teknikal mengenai penilaian, pemilihan, dan pengurusan teknologi penjagaan kesihatan; namun, pada masa ini

tiada garis panduan mengenai penyahtauliahan peranti perubatan dan tiada kajian sistematik tentang implikasi penyahtauliahan terhadap ekonomi, alam sekitar dan kesihatan rakyat sehingga kini. Penghapusan ketidaksamaan dalam akses kepada peranti perubatan menimbulkan masalah yang sukar kerana ia memerlukan analisis struktur pengawalseliaan, teknologi, pengurusan dan perolehan yang sedia ada.

Keywords: radiotherapy, X-ray machines, radiation treatment

INTRODUCTION

The machine may diverge from specs, provide false measurements, and jeopardise the quality, safety, and lifespan of the product without frequent calibration. Scaling and reconstruction errors can be caused by geometrical offsets, misalignments, and instabilities, which all reduce the precision of coordinate measurements made with commercial XCT devices. Next, to accurately calibrate the X-ray sources, the X-ray detectors must be calibrated. Therefore, this review discussed (a) the geometry calibration of x-ray computed tomography (b) the calibration of x-ray imaging devices (c) the importance of calibration should be taken care of to ensure the X-ray machines can be used optimally.

As new materials and medical technologies are produced, new medical devices are introduced daily to the market and health care systems. Therefore, it is essential to understand how to dispose of them securely and to verify that any reuse is permitted or authorised by the appropriate authorities. Decommissioning is the process of moving medical devices from the setting where they were first meant to be used, such as a hospital, to another setting where they would be utilised differently or discarded. Decommissioning medical equipment in the correct manner can improve patient safety and resource management, in addition to bringing about economic benefits. It is feasible to extend the useful life of these devices and guarantee that they can be securely relocated, donated, reused, or disposed of in an appropriate manner by knowing their life cycle and selecting the ideal end state for them

Radiotherapy, often known as radiation therapy, is a cancer treatment that use targeted radiation to kill or destroy cancer cells, therefore stopping them from growing or spreading [1]. Different forms of radiotherapy may employ various radiation sources, including x- rays, gamma rays, and proton beams. External radiation treatment machines are the most prevalent method of radiation therapy. However, before the radiotherapy can be used clinically, a medical physicist must conduct a number of tests and procedures along with the manufacturer to ensure the machine is fully functional and safe to use. These includes acceptance testing of the radiotherapy machine and equipment. Acceptance tests ensure that the purchase order specifications are met and that the environment is free of radiation and electrical dangers to employees and patients. The inspections are performed under the supervision of a representative from the manufacturer [2]. After passing the testing process, the physicists sign a document verifying that these standards have been satisfied. The unit is approved by the physicists, payment is made, and ownership is transferred to the institution, where the warranty period begins.

It is necessary to perform a radiation survey of each treatment area using a Geiger counter and a high-volume ionization chamber survey meter. For facilities with a 10 MeV treatment unit, neutron survey devices such as Bonner spheres, long counters, and boron trifluoride, BF_3 counters are required [3]. Contracting neutron measurements to a medical physics consulting service, on the other hand, may be a more cost-effective option than developing the highly specialized skills and knowledge required for most neutron measurements and attempting to acquire the expensive neutron detection equipment that is usually only required during acceptance testing [2].

ACCEPTANCE TESTING

Safety Checks

Radiation must be administered to a specified target region optimally for successful radiotherapy and to ensure patient safety. It must involve, in terms of the physical and technical characteristics of the therapy equipment, all radiotherapy equipment and procedures that are essential for the correct magnitude and precision of the therapeutic dose application, as well as the radiation safety of the staff and external persons [4]. All interlocks should be tested during the first safety inspections to ensure correct operation. The door interlock, every radiation beam-off interlock, every motion disable interlock, and every emergency-off interlock should all be subjected to these interlock checks. When the door to the treatment room is open, the door interlock stops radiation. The irradiation beam-off interlocks stop radiation but do not stop the treatment unit or patient treatment table from moving [2]. The motion disables interlocks stop the treatment unit and patient treatment table from moving, but they do not stop the machine from irradiating. The medical physicist should also ensure that all of these interlocks are working properly and that all personnel handling the device understand them. All warning lights should be examined after ensuring that all interlocks and emergency-off switches are working.

Acceptance testing is crucial since it has the potential to impact a system's performance across its entire lifespan. The need for acceptance testing should be stated in the instrument purchase agreement. This agreement should indicate who performs acceptance testing, the process to be followed if undesirable outcomes are found, and who supplies the necessary phantoms and software. Acceptance tests must be performed at a certain schedule [5]. Acceptance tests are carried out to ensure that the instrument meets its standards. Each instrument comes with a basic set of specifications. The manufacturer developed them using standard test procedures that should be traceable to standard protocols such as the NEMA [6] and IEC performance standards [7].

Mechanical Checks

The Winston-Lutz (WL) test is a common method in radiation therapy for determining the isocenter of a linear accelerator (LINAC) [8]. In contrast to other approaches such as room lasers and light field crosshairs, the WL test directly connects the radiation fields with the item being treated. Traditional WL tests use circular or square radiation beams to image a ball-bearing (BB) phantom on a sheet of film. The BB is projected inside the radiation beams, and pictures of it are created at different gantry, collimator, and couch angles [9]. Isocenter, a unique notion associated with a medical linear accelerator (LINAC), is applied on numerous occasions and in various combinations, including mechanical isocenter, radiation isocenter, rotation isocenter, imaging isocenter, therapy isocenter, and so on [10]. The couch, gantry, and collimator LINAC subsystems are considered as rigid bodies. Every point in a rigid body rotates in relation to every other point when the rigid body is in motion. A subsystem's rotation should be detected in a coordinate system that is stationary with respect to the LINAC vault in order to identify its axis of rotation (AOR). On the couch, gantry, and collimator, which rotate together with these subsystems, separate coordinate systems can be constructed.

Collimator Axis of Rotation

The connected circular bearing to the gantry rotates the photon collimator jaws. The rotational axis of this bearing should be parallel to the center axis of the photon, electron, and light fields, and the photon collimator jaws should open symmetrically about this axis. This axis is crucial to every treatment unit and should be properly determined. A stiff rod connected to the collimator housing can be used to locate the collimator rotation axis. This rod needs to be long enough to extend from its attachment point to the collimator housing to the isocenter's estimated location. It should also have a sharp tip at the end [3]. In order to determine the greatest deviation with collimator rotation, the gantry and treatment table angles are both set to zero, and the crosshair location is noted on the treatment table using graph paper as the collimator is rotated to 0°, 90°, and 270°. Two

distances should be used for the test. In most circumstances, this arc will decrease to a point, however its radius must not exceed 1 mm [11].

Gantry Axis of Location

Any rigid rod with telescoping capabilities can be used to locate the gantry axis of rotation. Numerous treatment devices come with a mechanical front pointer that may be utilized for this. The collimator's axis of rotation should be parallel to the front pointer's axis, and the tip has to be at the actual isocenter distance. As the gantry rotates, the location of an isocenter indication (either the crosshairs or an indicator connected to the gantry) is measured relative to a fixed point designating the isocenter position [3]. A second rigid rod with a tiny diameter tip is attached to the end of the patient treatment table, and the treatment table is then adjusted to bring the rod attached to the treatment table into contact with the point of the rod fastened to the gantry. The treatment table is then adjusted along its longitudinal axis to remove the tip of the rod from contact with the gantry rod. It is important not to alter the rod's vertical or lateral position. The gantry is rotated $180^{\mathbf{0}}$, and the treatment table is returned to the place where the two rods make contact. The pointers on the two rods should come into contact in the same relative location at both angles if the front pointer accurately calculates the isocenter distance. If not, adjustments are made to the treatment table height and front pointer length until this condition is as closely met as possible.

Patient Treatment Table

By setting up the gantry so that the collimator's axis of rotation is pointing vertically downwards, one can determine the axis of rotation for the patient treatment table [3]. The treatment table has millimeter graph paper attached to it, with the picture of the cross-hair marked on it. The movement of the cross- hair picture on the graph paper is seen while the treatment table is rotated. The cross-hair image should have a radius of less than 1 mm. In a sphere, the collimator axis of rotation, gantry axis of rotation, and treatment table axis of rotation should all coincide. The isocenter uncertainty is determined by the radius of this sphere. This radius should not be higher than 1 mm, and for radiosurgery devices, it should not be greater than 0.5 mm.

Dosimetry Measurement

The science of measuring radiation exposure and calculating it, or combining measurement and computation, is known as dosimetry [12]. A device, instrument, or system known as a radiation dosimeter measurement or assesses the quantities of ionized radiation either directly or indirectly [13]. The amount of radiation energy absorbed in tissues divided by the mass of the tissue is referred to as the absorbed dose. The absorbed dosage regulates how much radiation affects cancers and normal tissues. The higher the dose of radiation absorbed by tumors, therefore more cells that are destroyed by radiation and the higher the possibility of a cure. Together with the treating physician and the nuclear medicine technician, medical physicists with specialized knowledge in techniques for calculating absorbed dosage work. Based on the patient's specific biodistribution and clearance patterns from the body, the medical physicist then utilizes the dosimetry readings to determine a suitable treatment for the therapy. Dosimetry guarantees that the patient obtains a personalized, safe, and successful therapy in this way.

Dosimetry tests show that the clinical beams off axis characteristics and central axis PDDs are in compliance with the requirements. The properties of a LINAC's monitor ionization chamber or a ^{60}Co unit's timer are also established.

Photon Energy

Typically, the central axis PDD is used to express the energy specification of an X-ray beam. In the central axis PDD of a water phantom, the term standard parameters refer to the value of the 10 cm² field at a 10 cm depth. To estimate the nominal energy of the photon beam, this value is compared to values published in the British

Journal of Radiology Supplement 25 [14]. This value will be measured during acceptance testing using a small volume ionization chamber in a water phantom in line with the acceptance test methodology.

Arc Therapy

By altering a number of monitor units, MUs on a LINAC, or time on a ^{60}Co unit, as well as a range of degrees for the desired arc, the arc or rotational treatment specification is verified. Radiation termination and treatment unit movements shall be consistent with the specification. The normal range of readings is between 1 MU and 3^0. This test should be carried out for all treatment energies and modalities, as well as the range of arc therapy geometries for which arc therapy will be applied.

Calibration

X-rays can be produced by natural sources like the sun and stars. Natural background radiation can also come from the soil and the earth. Every person on the earth is subject to some radiation exposure in their everyday routines. Nevertheless, this kind of exposure is usually not harmful. Radioactive materials can be found naturally in the air, soil, water, rocks, and plants. Radon is the primary natural radiation source for most individuals. It is present indoors and outdoors as a colourless, odourless radioactive gas. The air, surface water, and subsurface and subterranean waters can all be affected by radon gas that is present in soil and rock [15]. Cosmic radiation, including X-rays, constantly bombards the Earth. Although these rays are not innocuous, they are inescapable, and because the radiation is so low, its effects are essentially imperceptible.

Other sources of X-rays are generated by machines such as medical x-rays produced by a technology built to emit radiation when instructed to. Electromagnetic radiation types called X-rays are similar to visible light. On the other hand, X-rays can penetrate across most solid objects, such as the human body, and have higher energy than light. Images of the tissues and structures inside the body are created using medical x-rays. If x-rays that are travelling through the body also pass through an x-ray detector on the patient's opposite side, the "shadows" cast by the objects inside the body can be seen in an image.

One of the most significant advancements in the profession over the past several years has been orthopedic templating. This treatment approach avoids complications and saves costs and time. Orthopedic surgeons can greatly benefit from digital templating. However, it relies on how the images are taken. To achieve the best outcome possible, methods must be considered. As a result, both the Radiology and Orthopedic teams must consider x-ray calibration. Especially when magnification radiography is involved. Magnification radiography is frequently used to produce an image larger than the investigated item. Depending on the aim, the x-ray source is frequently shifted closer or farther away to affect the magnification process. This is because the X-beam ray diverges from its source and moves in a straight line. The things closest to the detector will appear smaller and the ones impacted by the beam first will be magnified. Therefore, neither of the collected objects is its true size. But eventually, a surgeon needs to be aware of the precise measures, preferably before going into the operating room (OR). Magnification and measurement may be influenced by the anatomy of the patient. As a result, magnification must be considered. Otherwise, it could result in the wrong implant size, fractures, loosening, or even variations in leg length. However, x-ray calibration technology can be used to alleviate problems with orthopedics magnification. The process of calibrating an X-ray involves scaling the radiology image to the proper size so that the surgeon can accurately gauge the size of the body part, bone, or organ [16]. Knowing the appropriate fluoroscopic image magnification before entering the or significantly enhances the outcome.

The Geometry Calibration of X-Ray Computed Tomography (XCT)

X-ray computed tomography (XCT) is an imaging method that makes use of a medium's attenuating characteristics when x-rays pass through it. XCT has been widely employed in the medical sector as a technique to visualize internal organs ever since it started to be produced.[17]. Recently, XCT has gained recognition as a useful technology for measuring the coordinates of assembled and complex parts [18]. There is a tremendous

demand for quality measures and calibration techniques because XCT is used so often by manufacturers and other industrial customers. It is essential to analyse measurement uncertainty specifically for the use of verifiable coordinate measurement in the deployment of XCT [19]. Numerous variables that have an impact on the measuring process are the main cause of the inaccurate coordinate data measured on the XCT system [20]. Geometrical offsets, misalignments, and instabilities can result in scaling and reconfiguration errors, both of which are detrimental to the accuracy of coordinate measurements conducted on industrial XCT systems. It is important to note that geometrical calibration alone is insufficient to calculate measurement uncertainty because there are non-geometric influencing factors. Geometrical calibration is a crucial component, though, in order to assess the XCT measurement's level of uncertainty and establish measurement traceability.

Projective geometric ideas serve as the foundation for the development of an XCT system. The shape of the x-ray beam that is focused onto the detector by a source determines its shape. Industrial XCT systems employ two types of x-ray beam configurations. The first type of beam is shaped like a cone and has a wavefront that diverges as it moves away from the source. In a cone-beam system, the detector is a flat 2D panel. The fan-shaped (fan-beam) second type of x-ray beam can be incident on either a straight- or curved-line detector. Multiple linear slices must be obtained and patched together for a fan-beam system to photograph the same area as a cone-beam system [21]. One advantage of fan-beam systems is the absence of cone-beam effects because of the parallel beam geometry and a reduction in scattered radiation that is detected by the smaller detector.

Two categories of XCT system geometry determination techniques are described in the literature. The rotation stage's geometry is considered in the first category for a fixed kinematic position. One of these methods is imaging an indicator and figuring out the imaging geometry via output data, like radiography. Therefore, in this review, these techniques are referred to as "imaging techniques". X-ray focus area drifts and the rotation stage's characteristics because of rotation location are both considered by some imaging techniques. Only particular, kinematic rotation stage positions are useful for imaging procedures; if this happens, a new evaluation of the geometry is required. Because of this, the second group of approaches considers the kinematic assembly's incorrect motions. These techniques rely on the measurement of kinematic behaviours using reference tools like laser interferometers and electronic levels.

The Calibration of X-Ray Imaging Devices

In the past, X-ray imaging was employed to locate geometric and qualitative intensity information, such as tooth decay or star luminosity. Accurate X-ray intensity measurements in each energy range are now more crucial than ever for a variety of fields, such as plasma physics, non-destructive testing, health, and astronomy. Procedures for calibrating X-ray imaging systems have been produced by National Security Technologies (NSTec). Both diode-type and diode/fluorescent combos of X-ray sources are employed for calibration [22]. For the X-ray sources to be accurately calibrated, the X-ray detectors must be calibrated.

Devices that use X-ray imaging are calibrated using X-ray sources. With the use of calibrated detectors, the X-ray source flux, flux distribution, and spectrum are all measured. The X-ray sources that are used to calibrate imaging systems include the High Energy X-ray Source (HEX) and the Medium Resolution X-ray Source (MRXS). HEX uses a commercial 160 kV tungsten X-ray tube with fluorescing targets that are contained in a lead box to generate spectral lines in a beam. With the help of this technique, detectors can be calibrated over a wide range of clearly defined energies at relatively limited spectrum energy. A variety of equipment is evaluated and calibrated using the MXRS, a diode-type X-ray source.

Procedures for quantitatively calibrating various X-ray imaging systems have been developed. The processes, which encompass the energy range from 500 eV to 115 keV, were developed utilising the two stable X-ray sources HEX and MRXS. The method's core step involves calibrating the detectors being used to gauge source intensity against NIST traceable standards. Photodiodes and energy-dispersive detectors are calibrated using radioactive sources and a synchrotron. The calibrated detectors enable measurements of source intensities with several percent accuracies. The sources can then be used to calibrate X-ray imaging equipment for both the average quantum efficiency and the variance in performance over the detector region.

Importance of Calibration

The services that facilities provide their patients must include the appropriate maintenance and care of their x-ray equipment. Healthcare facilities must maintain their imaging equipment proactively to ensure that it is in good operating condition. The calibration of both the stationary and portable X-ray devices is a part of that maintenance. It is impossible to emphasize the value of consistent calibration. When the machine is regularly calibrated, many issues can be quickly identified and resolved. Regular calibration will also help to guarantee accurate output and patient doses that are safe. For veterinary clinics, Diagnostic Imaging Systems advises calibrating portable and stationary x-ray machines every two years, and for chiropractic and medical clinics, every year [23]. To ensure the machine lasts if feasible, calibration is required. The calibration will also reduce the possibility of second x-rays produced by excessively or inadequately exposed images. Additionally, it will ensure that the region of interest is exposed and focused on. Knowing the influences that could cause systematic errors is crucial when calibrating a system. The examples of significant variables that have been shown to cause errors in dimensions data produced by an XCT machine are environment, object, detector. X-ray source, manipulation system and data processing [24]. However, that is not a comprehensive example, and as we understand more about the nuances of each XCT system's operation, new failure factors will probably be included.

Decommissioning

Medical equipment is defined by the World Health Organization (WHO) as requiring maintenance, repair, user training, and decommissioning [25]. A medical device is a piece of equipment that is used to prevent, diagnose, treat, monitor, or alleviate a disease or sickness. It can also alter anatomy and regulate conception. The purposes of it are: diagnosis, monitoring, prevention, treatment or alleviation of disease or an injury, investigation, modification, replacement, or support for a physiological process, supporting or sustaining life, disinfection of medical devices and providing information by means of in vitro examination derived from the human body.

Decommissioning refers to the process of moving medical equipment from the setting where it was designed to be used, such as a hospital or clinic, to another setting where it will be put to a different purpose or discarded entirely. The fact that many essential medical devices still fail to reach hospitals and health care centres in low- and middle-income countries.

Medical Devices

Medical devices can be categorised based on the level of control required to assure their safety and efficacy. As this is a risk-based categorization, the primary element in determining the device's class is the risk it poses to the patient or user [26].

After January 2021, when the United Kingdom leaves the European Union, devices sold in the United Kingdom will bear the UK Conformity Assessed (UKCA) mark. European Conformity (CE) or UKNI markings will be required for goods sold in Northern Ireland. In the United Kingdom, approved devices are registered with the Medicines and Healthcare products Regulatory Agency (MHRA). The MHRA is responsible for guaranteeing the effectiveness and safety of medical devices. Each medical equipment is classified into one of three types based on the risk posed by improper usage or its complexity which are; class I: low risk (e.g., surgical instruments, stethoscopes, and bandages); class II: moderate risk (e.g., an ECG monitor) and class III: high risk (e.g., a defibrillator, pacemaker, or breast implant).

There are primarily three categories of medical equipment, (1) General medical devices for example, a heart valve, X-ray equipment, or a dressing, (2) Active implantable devices for example, a cardiac pacemaker, nerve stimulator, or a cochlear implant, (3) In vitro medical devices: for example, pregnancy test or blood group reagent.

Class I devices are not intended to assist, support, or sustain life, and they are not permitted to pose any unreasonable risks of disease or injury to the user. For Class 2, in addition to being subject to regular restrictions, certain devices are also subject to the specific controls. Special controls are a form of regulatory control that is

special to a device and serves the purpose of ensuring that the device functions as intended. The devices for which general control alone is unable to guarantee the devices' safety and effectiveness will require additive control that is comparable to that of the devices that are already approved. Class 3 devices will include any devices for which even additional special controls in addition to general controls are unable to provide sufficient assurance for the safety and effectiveness of the device, and which require premarket approval in order to undergo a review concerning the device's safety and effectiveness. These machines are designed to assist and maintain human life functions in order to fulfil their primary purpose.

The process of selecting and commissioning medical devices attracts a lot of attention, whereas the processes of decommissioning and disinvestment are regarded as less interesting and either aren't handled at all or are postponed since there is a lack of knowledge on how to proceed. Devices that should be decommissioned have the potential to cause harm to patients or health care professionals and should, as a result, receive the appropriate attention.

Life Cycle

There a four main phase lifecycle of medical equipment are:

i. Planning and assessment
ii. Set-up
iii. Use and Maintenance
iv. Disposal

Planning and Assessment

In most cases, the planned replacement of healthcare equipment will require the participation of multiple members of the healthcare team, including administration, clinicians, key department managers, supply chain, facilities, information technology, and Clinical Engineering (CE).

Set-up

During the phase known as "setup," the medical supplies and devices are transported to the location where they will be used and then set up there. The staff has received training on how to operate the various pieces of machinery. The training of staff members on how to use the equipment may require setting aside specific amounts of time and space for the training sessions, as well as educational materials, somebody who is qualified to deliver the training, and consideration given to how to motivate staff members to attend the training.

Use and Maintenance

During the use and maintenance phase of the equipment lifetime, the equipment is utilised. This includes monitoring compliance with safety measures and regular training of healthcare professionals, including new employees, on how to use the equipment. Certain equipment requires a constant supply of energy, water, or medical gases. Some equipment may require particular storage conditions. If a piece of equipment breaks, qualified staff will need to be able to identify the problem and obtain reasonable replacement components.

Disposal

During this phase must address who will determine when the equipment needs to be updated and if there are any unique criteria for the safe disposal of items such as sharps, hazardous materials, and confidential data. All of these obstacles may be easily surmountable, and the needs for various types of equipment will inevitably vary greatly. However, it is essential to sketch out the whole lifecycle of a piece of equipment to ensure that you do not overlook something crucial to the donation's success. Both single-use and reusable medical equipment need to undergo decontamination before the decommissioning process can begin.

Decommissioning

Permanent elimination in example recycling, cannibalization, or incineration and re-use such as donation, sale, refurbishment, reprocessing, trade-in, or internal reassignment are the two primary routes for decommissioning a medical device and determining its final disposition following decontamination [27].

The reasons that decide which of the two decommissioning pathways is pursued can be categorised as those intrinsic to the device, to the infrastructure in which it functions, is being utilised, or is transiting, and as those connected to administrative and policy decisions. Among the device's intrinsic factors are: single-use designation, inadequate disinfection or sterilization, unresolved performance issues, unresolved safety issues, continuous unreliability or history of serious failure, high cost of repair making the device cost effective or financially unviable

Improper classification for decommissioning involves determining that a medical device is obsolete after the introduction of a new model [28]. As obsolete products are typically supported by their manufacturers and third parties for a number of years, the availability of a new model should not necessarily result in decommissioning. Decommissioning and the acquisition of a new version of a medical equipment should be considered only if the manufacturer or supplier no longer provides service. Prior to making a decision to decommission a medical device, its necessity should be thoroughly evaluated.

Regulation 15 of the Health and Social Care Act of 2008, assures that device used to provide care and treatment is maintained, stored, and cleaned as intended [29]. Failure to comply with the law can result in defective materials, which can negatively affect surgical outcomes. An example of this is the 2009 Poly Implant Prothèse (PIP) breast-implant crisis, in which imlants were made using a cheaper, non-approved silicone that was prone to rupturing and causing inflammation, scarring, and agony in millions of women worldwide. To ensure effective management, prevent waste, and minimise the danger of harmful exposure to staff, the general public, and the environment, it is crucial to accurately establish the final disposition of a retired medical equipment.

CONCLUSION

Following installation, the physicist performs acceptance testing to check that the equipment meets the product details and the purchase contract. The facility physicist and the manufacturer's representative established an acceptance testing protocol, which is followed during these tests. Acceptance testing equipment should be provided at each facility [30]. The different acceptance tests performed for mechanical, X-ray beam characteristics, flat panel detector performance, collision safety, and radiation safety revealed that the findings are within the permitted limits and tolerances suggested by international agencies. This enables the simulator's dependable performance and operation, which is required for the further transfer of proper anatomical imaging data with tumor localization to a radiation unit for effective patient treatment [31].

It is crucial to have the expertise to assess the necessary measurement uncertainty if the objective of ensuring the traceability of measurements conducted on XCT systems is to be accomplished. An industrial cone-beam XCT system's geometrical design was presented, along with the different offsets and misalignments that affect the accuracy of measurements. The calibration of imaging devices is also introduced using two different kinds of X-ray sources. The average quantum efficiency and the variation in effectiveness over the detector area can be determined by using the X-ray sources to calibrate the X-ray imaging apparatus. Following that, approaches for estimating geometrical errors are discussed. First, imaging techniques that rely on imaging reference objects are given. The evaluation of fixed imaging geometries is well-suited for these imaging techniques. Kinematic positioning systems, which enable the translation of the rotation stage in the measurement volume, are frequently included in industrial XCT systems. The final section of this review discusses the influences that lead to XCT system faults. It is crucial to understand the influencing elements that could cause systematic errors when calibrating a system.

The Medical Equipment Replacement Plan is an objective instrument for guiding replacement decisions. It must incorporate expert input from a variety of sources, including Clinical personnel, CE, materials management, and

administration. A rational plan for the replacement of medical equipment can be devised when nontechnical considerations and hospital financial constraints are considered. Immediate benefits include a huge reduction in emergency equipment replacement purchases and an improvement in the safety and efficacy of clinical technology. The process of planning for the replacement of medical equipment is an essential component of the overall technology planning process. In order to demonstrate the importance of this field, clinical engineers ought to assume leadership positions in the relevant fields. As a result of these efforts, CEs are equipped with the skills, knowledge, and information necessary to serve as an extremely important resource for the health care industry.

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