QUALITY ASSURANCE (QA) AND QUALITY CONTROL (QC) IN RADIATION TREATMENT- A SHORT REVIEW

Nur Syahirah Abdul Razak, Tuan Khairunnisa Nabilah Tuan Abdullah and Siti Amira Othman*

Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia, 84600, Pagoh, Johor

sitiamira@uthm.edu.my

ABSTRACT

An overview of quality control in radiotherapy equipment was given in this work. Complex processes and tests are necessary when buying new radiotherapy equipment, and they fall within a quality assurance program. The processes for monitoring (or testing) and maintaining the technical components of the equipment are crucial elements in the quality assurance (QA) program, and they are both included in the quality control (QC) program. In addition, this paper examines the procedure for buying new equipment, which is then put through a series of tests before an institution accepts it. Additionally, clinical consistently applies quality assurance to create a clear organisational framework regarding accountability for duties.

ABSTRAK

Gambaran keseluruhan kawalan kualiti dalam peralatan radioterapi telah diberikan dalam kerja ini. Proses dan ujian yang kompleks diperlukan apabila membeli peralatan radioterapi baharu, dan ia termasuk dalam program jaminan kualiti. Proses untuk memantau (atau menguji) dan menyelenggara komponen teknikal peralatan adalah elemen penting dalam program jaminan kualiti (QA), dan kedua-duanya termasuk dalam program kawalan kualiti (QC). Di samping itu, kertas kerja ini mengkaji prosedur untuk membeli peralatan baharu, yang kemudiannya melalui beberapa siri ujian sebelum institusi menerimanya. Selain itu, klinikal secara konsisten menggunakan jaminan kualiti untuk mewujudkan rangka kerja organisasi yang jelas mengenai akauntabiliti untuk tugas.

Keywords: Quality assurance, clinical, radiotherapy, testing, maintenance

INTRODUCTION

A program called quality assurance was created to encompass practices and systems managed by businesses by standards to limit potential patient exposure and produce diagnostic images of the highest calibre. The company will be accountable for maintaining quality in its building. To avoid mistakes and errors, a quality assurance procedure is essential and comprehensive. Every clinical trial employ systematic quality control. As a result, a specific field of clinical research has produced practices that are gradually being adopted by the entire radiation community, both inside and outside of clinical research. The responsibilities for general operations and quality assurance should be clear to every employee.

Medical physicists with clinical training and radiological medical practitioners are the specialists executing quality assurance procedures in the clinical setting. A practising certificate in medical physics is necessary, as is the Continuous Professional Development (CPD) requirement, which calls for 30 points of yearly growth [1]. The quality assurance process includes QC techniques and quality management procedures [2]. The processes for monitoring (or testing) and maintaining the technical components of the equipment are often included in the QA program, according to the earlier study that was cited. A quality control program will be put in place before making equipment purchase plans to guarantee optimal performance from all equipment, lower radiation dose, enhance image information, and save operational expenses.

According to Kareem et al. [2], a QC program for new equipment may typically consist of the following: initial planning to buy new equipment, a required acceptance test, installation of new equipment followed by a consistency test, status test to update the status of equipment and equipment quality consistency. The equipment will undergo a performance test, an acceptance test to determine whether it should be accepted or refused, verification, and documentation-based follow-up.

A reactive QC is undesirable because the patient basically takes the place of the phantom in the testing process. A proactive quality control approach is necessary. Quality control tests are carried out according to a planned schedule, in unregulated environments, and with distinct pass/fail standards. In other words, the quality control process used by the Department of Digital Radiography ensures that the equipment's operation is assessed before it is used to take pictures of patients.

QUALITY CONTROL FOR EQUIPMENT

The goal of quality control procedures and testing for X-ray equipment is to verify the mechanical stability of the apparatus and the dependability of its security measures, such as interlocks and auditory alarms. QC tests also confirm the functionality of display screens and other related devices. Assessing the system's diagnostic performance, which includes figuring out the radiation dosage, is vital. All of them are a part of the radiology quality assurance program [3].

The equipment determines how long it will be subject to quality monitoring. Some machinery needs to be tested every day. Daily quality control checks for digital radiography equipment involve warming up all parts that are frequently used for imaging, like displays and printers. Every time the equipment has been idle for a while, a warm-up is required. According to the manufacturer's recommended procedure, a dummy may be required for the warm-up test. National evaluation of X-ray trends) phantoms made of acrylic and aluminium have been developed based on FDA NEXT surveys.

The radiology quality assurance program includes daily checks of all meters, as well as the auditory and visual signals on digital X-ray equipment, in addition to warm-up testing. Every day, a visual inspection of the X-ray apparatus is performed to look for any loose parts or operating vibrations. A thorough visual inspection of image-interpreting electronic display displays is part of the daily examination of digital equipment [4]. The radiology quality assurance program includes daily checks of all meters, as well as the auditory and visual signals on digital X-ray equipment, in addition to warm-up testing. Every day, a visual inspection of the X-ray apparatus is performed to look for any loose parts or operating vibrations. A thorough visual inspection of image-interpreting electronic display displays is part of the daily examination of digital equipment [4].

This is an important component of the program for ensuring radiological quality. Monthly retake analysis helps to spot trends and stop errors from happening again. A 5% or lower retake rate is advised. Additionally, using test patterns, the functionality of electronic display devices is assessed monthly. Using test patterns, the laser film printer's image quality is assessed.

QUALITY CONTROL FOR X-RAY

To guarantee that equipment operates properly, a quality assurance program will be developed and evaluated. This program will include several equipment performance inspections and testing. The introduction of new machinery, like an X-ray machine, will allow for the establishment of this program. The accuracy of the diagnosis will be assessed, the outcome will be optimized, and finally, the radiation dose will be kept to a minimum.

Typically, high voltage is accelerated and collides with a metal target to produce X-rays. Understanding the underlying mechanism allows for the design of the X-ray to be considered, such as the need for the focal spot size to be as tiny as feasible to provide a sharp image. The size of the focal point is the main factor in picture quality. A small focus point size is necessary to get an X-ray image with less blur. The heat and strain on the focusing spot area are more likely to be concentrated in a small, focused point.

The anode surface could melt if the heat generated during a single exposure is greater than what the track can handle. For optimal X-ray generation, the anode's composition, surface area, and angulations must be just right. To avoid overheating, pick between fixed and spinning anodes. An effective heat dissipation system is required to cool the target [5].

A set of tests must be carried out after the installation of a treatment machine to certify the unit's performance parameters. Once the unit has been certified, a thorough series of measurements must be finished before the device can be used in clinical settings. These measurements also provide crucial information (baseline standard) for the QA program for a treatment machine [3]. Congruence of radiation and light field, beam alignment, field size at 1 m from focus, minimum focus on skin distance, light beam illumination, measurement of focal spot size using focal spot test, tube voltage accuracy, exposure time accuracy, consistency of output Gy/mAs, consistency of kVp, consistency of exposure time, and lastly tube output variation of Gy/mAs with kV are some of the quality control tests for general X-ray machines [2].

STANDARDS OF CLINICAL QUALITY FOR RADIATION TREATMENT

Running clinical procedures is also part of the quality assurance program. Radiation treatment carries out each step; prescribed dose, treatment planning, and patient-positioning refer to the QA program to perform high-quality physical treatment delivery. A guideline for quality assurance in Radiotherapy was published by the World Health Organization (WHO) in 1988. Report number 13 from the American Association of Physics in Medicine. Physical elements of radiation treatment quality assurance (1994). In 2003, the Organization of European Cancer Institutes established the Clinical Assessment Guide. Various research institutions publish research to provide information and set the standard of clinical quality for radiotherapy [4]. Bogusz 2012 compiled in his previous research stated the clinical standards were divided into the following categories:

- Referral for treatment/decision to treat/treatment prescription.
- Therapeutic (treatment) protocol.
- Interdisciplinary approach.
- Communication.
- Treatment planning.
- Verification of treatment plan, irradiation time, and radiotherapy form.
- Treatment delivery.
- Verification of treatment delivery.
- Termination or withdrawal of treatment.
- Medical accidents and radiological events.
- Treatment quality control.
- Radiation dose reference levels.
- Documentation and records.

Follow-up.

- Clinical audits.

The standard of clinical quality of radiotherapy is established to manage the quality system and improve the work organization. This helps to reduce the number of non-conformities and failures.

One in every ten Malaysians, whether adults or children, will be diagnosed with cancer during their lifetime. One of Malaysia's health issues is the rising number of malignancies. Cancer is the second leading cause of death globally, accounting for an estimated 9.6 million deaths, or one in six deaths, in 2018 [6]. Cancer can develop in almost any organ or tissue in the body, making it a diverse illness. These disorders are characterized by uncontrollable aberrant cell proliferation that infiltrates nearby body tissues and can spread to other organs. The latter phase, known as metastasizing, is one of the leading causes of cancer-related deaths. The global cancer burden continues to rise, putting enormous physical, emotional, and financial strain on patients, families, communities, as well as healthcare systems. In this huge nation across countries, there are huge gaps or differences when it comes to health systems between low- and middle-income countries. It shows that the survival rates for cancer patients in countries that have stronger health systems are higher because of the improved accessible early detection.

As previously stated, radiation is one of the cancer treatment modalities or procedures. Radiation therapy, sometimes known as radiotherapy (RT), is a type of cancer treatment. In this treatment procedure, high doses of radiation are delivered to tumors to heal, control, and reduce sickness symptoms. To kill cancer cells, this therapeutic approach employs high-energy ionizing radiation. However, some radiation doses will be received by neighboring areas, which may have detrimental consequences. To treat cancer and manage its symptoms, radiation treatment is used or recommended to kill cancer cells by destroying their DNA (deoxyribonucleic acid). The treatment modality stands for therapeutic methods or procedures for instance surgery, it is stated that when focusing on cancer treatment, radiotherapy (RT) can be given alone or in combination with other modalities such as surgery, chemotherapy, and hormone therapy [7].

In radiotherapy treatments, it can be delivered in two ways which are teletherapy or known as External Beam Radiotherapy (EBRT). This procedure of treatment is produced by machines called Linear Accelerators that will be directed to the specific part of the body that needs to be treated [8]. For instance, Acute Lymphocytic Leukemia (ALL) which is a type of cancer of the blood and bone marrow mainly uses EBRT as treatment. The radiation team will take careful measurements to determine the correct angles for aiming the radiation beams and the correct doses of radiation patients need before starting the procedures of treatment. EBRT is also used in breast cancer treatment.

To get all the processes of radiotherapy to work in smooth and quality ways, clinical quality standards are needed in the medical field [9]. Clinical quality standards are critical for attaining and executing smooth procedures in the healthcare system, notably in radiation. In the field of radiation, the accuracy, and detail in the patient's medical history, treatment planning, and dose prescription are critical. Quality standards are the set of acceptance criteria against which the quality of the activity in question can be assessed. It is applied in all countries with their standardized clinical quality standards, where in 1988 the World Health Organization (WHO) issued the recommendations in clinical standards for radiotherapy and the IEC, as well as the Institute of Physics and Engineering in Medicine (IPEM) in 1999, also issued the certain part of radiotherapy process. From this, there are numerous quality standards were introduced to ensure a smooth process in the clinical field.

Quality standards are divided into three categories which are organizational, physical and technical, and clinical standards. Pitch into the clinical quality standards, several standards need to be followed by the multidisciplinary radiotherapy team that oversees managing, treating, and caring for cancer patients for instance, clinical oncologists, medical officers, physicists, radiation therapists, and nurses. In clinical quality standards, all the categories have various numbers of standards that the multidisciplinary radiotherapy teams in charge must follow to get a very detailed and smooth procedure for each radiotherapy treatment to the patient [10]. It is very crucial for radiotherapy which requires intense attention to detail, alertness, precision, and adequate human and material resources to minimize the risk of irreversible consequences. It is an essential part of radiotherapy to have organizational, physical technical, and clinical quality standards to ensure the effectiveness and safety of radiotherapy treatment to the patient.

In 2020, the COVID-19 pandemic had a huge impact on the world and every country was infected. A total of 6.5 million infections have been documented, and the COVID-19 pandemic caused by the SARS-COV-2 virus has claimed 380,000 lives globally [11]. The Covid-19 pandemic in Malaysia, which lasted two years and produced almost 6 million cases, in all industries, including medicine, it altered many categories. As COVID-19 continues to spread and challenge society and professional norm, it has pushed radiotherapy in the world into unprecedented transformation [12]. Since the COVID-19 outbreak, there have been sudden changes in clinical physicist tasks with no historical precedent. In every department to safeguard cancer patients, medical professionals, and caregivers, as well as to coordinate therapies for patients with positive or suspected COVID-19 cancer, prevention, and control measures, including radiation oncology facilities, are in place. The medical physicist provides the most supporting roles as well as others in RT to execute all the tasks safely and efficiently, where they all perform or operate in teams that organize the procedure smoothly.

CONCLUSION

In conclusion, quality assurance at a radiotherapy facility is a team effort that is vital for accurate and precise patient irradiation. Every department needs to take part in these responsibilities to handle the procedure and test well. Since a radiation department is both a clinical and technological entity, radiotherapists, physicists, engineers, and radiographers must have their quality assurance duties. The facility should develop a better-quality assurance program to provide better patient service. The quality assurance methods at a radiotherapy institute should be thoroughly evaluated, especially for equipment. Complex radiotherapy equipment is susceptible to failure. Every QA process should routinely include frequent local audits. Whenever possible, a random selection of patient charts should be reviewed. An eligibility and treatment compliance check should be undertaken as early as feasible.

In a nutshell, the proposed clinical quality standards were used in any institution employing ionizing radiation for medical purposes. Yet, it needs to be implemented and reviewed regularly to enable verification of whether all the pre-set standards comply with the treatment. It is very important in clinical quality standards to improve through the quality management systems functioning where it gives focus on:

- Improvement of work organization
- The quality of service provided to patients.
- The reduction in the number of non-conformities and failures, cost of the failures, and technical breakdowns
- The rising number of patients and staff safety through ongoing control of equipment and workplace
- The creation of a clear organizational structure about the responsibility assigned.
- The strength of teamwork and cooperation between staff members and organizational units
- The increased commitment of the staff to continuous improvement of the institution and its Quality Management System (QMS).

REFERENCES

[1] Wong, J. H. D., Yeong, C. H., Zin, H. M., Pawanchek, M., Jamal, N., & Ng, K. H. (2020).Medical Physics Development in Malaysia. Medical Physics International 8(3), 434–437.

[2] Kareem, A.-J. A., Hulugalle, S. N. C. W. M. P. S. K., & Al-hamadani, H. K. (2017). A Quality Control Test for General X-Ray Machine. Wsn, 90(November), 11–30. http://www.worldscientificnews.com/

[3] Huq, M.S., Fraass, B.A., Dunscombe, P.B., Gibbons Jr, J.P., Ibbott, G.S., Medin, P.M., Mundt, A., Mutic, S., Palta, J.R., Thomadsen, B.R. and Williamson, J.F. (2008). A method for evaluating quality assurance needs in radiation therapy. International Journal of Radiation Oncology* Biology* Physics, 71(1), pp. S170-S173.

[4] Bogusz-Czerniewicz, M. (2012). Clinical quality standards for radiotherapy. Wspolczesna Onkologia, 16(1), 44–52. https://doi.org/10.5114/wo.2012.27336

[5] Ng, K.H., Rassiah, P., Wang, H.B., Hambali, A.S., Muthuvellu, P. and Lee, H.P. (1998). Doses to patients in routine X-ray examinations in Malaysia. The British journal of radiology, 71(846), pp.654-660.

[6] Lim GCC. (2006). Clinical Oncology in Malaysia: 1914 to present. Biomed Imaging Interv Journal 2(1): p18.

[7] Rubiah Mohd Pakeh and Nafisah Hamid. (2017). Radiotherapy in General. Portal MyHEALTH. Retrieved via http://www.myhealth.gov.my/en/radiotherapy/

[8] Hizam, N. D. A., Ung, N. M., Jong, W. L., Zin, H. M., Rahman, A. T. A., Loh, J. P. Y., & Ng, K. H. (2019). Medical physics aspects of Intensity-Modulated Radiotherapy practice in Malaysia. Physica Medica, 67(October), 34–39. https://doi.org/10.1016/j.ejmp.2019.10.023

[9] McKenzie, A. (2009). Quality assurance in radiotherapy. NATO Science for Peace and Security Series B: Physics and Biophysics, 39, 71–79. https://doi.org/10.1007/978-90- 481-3097-9_5

[10] Mijnheer, B. J. (1992). Quality assurance in radiotherapy: Physical and technical aspects. International Journal for Quality in Health Care, 4(1), 9–18.

[11] Willoughby, T., Lehmann, J., Bencomo, J.A., Jani, S.K., Santanam, L., Sethi, A., Solberg, T.D., Tomé, W.A. and Waldron, T.J. (2012). Quality assurance for nonradiographic radiotherapy localization and positioning systems: report of Task Group 147. Medical physics, 39(4), pp.1728-1747.

[12] Khan R, Darafsheh A, Goharian M, Cilla S, Villarreal-Barajas JE. (2020). Evolution of clinical radiotherapy physics practice under COVID-19 constraints. Radiother Oncol. 148:274-278. doi: 10.1016/j.radonc.2020.05.034.