Research and Innovation in Technical and Vocational Education and Training Vol. 3 No. 1 (2023) 046-051

RITVET

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/ritvet
e-ISSN : 2785 – 8138

Remote Afterloading Technology: A Short Review

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DOI: https://doi.org/10.30880/ritvet.2023.03.01.006
Received 31 March 2023; Accepted 04 June 2023; Available online 30 June 2023

Abstract: Afterloading is a medical technique used in radiation oncology in which catheters with or without applicators are placed inside the patient's body during the surgery. Respective radioactive sources are also loaded into the patient for treatment. There are remote afterloading of low-dose-rate (LDR), medium-dose-rate (MDR), and high-dose-rate (HDR) radioactive materials for brachytherapy is increasingly performed. This review presents the importance of remote afterloading technology discovery that successfully benefits today's radiation therapy and treatment. Remote afterloading offers great advantages such as improved radiation control,provides technical advantages. The choice of a particular remote afterloading device depends on afew important perspectives such as the patient population. Despite any type of remote afterloader, radiation control procedures are vital as manual afterloading technology. To reduce patient suffering, shorten hospital stays, and remove radiation risks to medical staff, the first remote afterloading technique was introduced in 1964. It included transferring tiny, highly active cobalt sources back and forth. Although this remote afterloading is an improvement over the manual, radiation risks are still present. Therefore, theremote afterloading machine's safety design was developed to lower the radiation threats.

Keywords: Remote Afterloading, Radiation, Radioactive, Brachytherapy

1. Introduction

In the Medical field, remote afterloading of radioactive materials is becoming more common, particularly for brachytherapy. Beginning in the early 1960s, brachytherapy was performed in England, Europe, and a few locations in the United States using upgraded versions of the original remote afterloading devices. These gadgets were initially only produced by a small number of companies. Devices with a wide range of functions are available from several contemporary manufacturers. Radiation oncologists use remote afterloading brachytherapy in a variety of anatomic locations, according to a study of the proceedings of the meetings 2–7 supported by the equipment makers (Isnaini et al., 2019). Now in Malaysia, this machine is already has especially at several Hospitals.

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A method or equipment known as remote afterloading autonomously delivers a radiation source to the tumour, minimising radiation exposure to the medical staff and the surrounding healthy tissue (Verma et al., 2020). The afterloading procedure begins with the first insertion of an applicator into the patient, either manually using a hand or automatically using a machine thatloaded radioactive sources. In particular, when the units malfunction and the sources become stuck in the applicators, remote afterloading systems pose a unique set of radiation restrictions.

Even though manual afterloading lowers exposures, the guiding concept of radiation protection is to maintain exposures as low as reasonably practicable (ALARA) given the present economic, political, and sociological conditions. Remote afterloading was used in an effort to further limit exposures. To provide radiation dosage, this technique uses hollow tubesthat are attached to a safe that houses a tiny radioactive source that is held by a wire and moved to predetermined positions by a stepping motor (Tačev et al., 2003).

To deliver the therapy, these gadgets work remotely. An outline of the stepping motor's patterns is made. Only after all personnel have left the protected space where the patient is kept throughout the course of treatment is the motor activated (Tortorelli et al., 1994). Thus, the treatment can be initiated by the nurse or therapeutic radiographer outside ofthe room. Catheters are inserted into the patient while they are empty, and the "live" source isadded later (Armstrong, 2022 and Heinrich et al., 1994) . This allows for the repositioning and inspection of the inactive dummy guides. Toput it another way, the source is not positioned into the guides until it is suitable. A pneumatic drive wire is then sent through it by the machine. The source then exits its safe location whenthe check has been completed, and treatment starts (Glasgow and Corrigan, 1995). Due to the numerous radiation safety concerns with manual afterloading machines, remote afterloading machines have been developed; however, they are more expensive and prone to error (Grigsby et al., 1995).

Reduced radiation exposure for radiation oncologists, physicists, attending doctors, source curators, nurses, and other allied health professionals is a benefit of remote afterloading (Nastya, 2020).When compared to manual afterloading, remote afterloading has a lower chance of either permanently misplacing radioactive sources or actually losing sources. Next, no rush to placethe sources in theatre-more time to optimize the implant. Then, treatment is verified and planned prior to delivery. The disadvantages of remote afterloading are this machine is very costly to maintain. Afterloading is a medical technique in radiation oncology in which a catheter, with or without an applicator, is placed into the patient's body during surgery. A suitable radiation source is also loaded into the patient for treatment. A dosimetry study is required prior to each loading session. Reloading, on the other hand, can be done manually or using a remotely operated reload machine. Especially with remote reloading, complete radiological protection of medical and nursing staffand visitors is very important.

Nevertheless, it improves the geometry and thus the quality of the dose distribution of theapplication or injection. This is due to the ability to precisely position catheters and needles withoutexposing them to radiation (Van and Saw, 2013). In other words, remote afterloading techniques are more sophisticated techniques in which radioactive isotope seeds are implanted into the tumor area or amachine inserts the source into an applicator to reduce the radiological risk for the operator (Isnaini et al., 2019). In addition, remote reloading has three radioactive materials: low dose rate (LDR), medium dose rate (MDR), and high dose rate (HDR) remote reloading.

Remote afterloading offers great advantages such as improving radiation control, providing technical advantages as well as optimizing isodose distribution. All of these improve care for patients. Besides, remote afterloading technology also replaces manual afterloading. Hence, radiation exposure by radiation health workers can be reduced (Akiyama et al., 2012). Moreover, remote afterloadinggives out less chance of losing or misplacing radioactive sources and any possible unwanted events that happen with manual afterloading.

However, the remote afterloading technique also has some drawbacks. For example, remote afterloading devices typically cost between $150,000 and $300,000, which is quite a lot. In that case, the cost of retrofitting a traditional hospital room to accommodate the unit could require an additional $50,000 to $100,000. Additionally, radiation therapy rooms cannot accommodate the desirable X-ray imaging equipment needed for source localization. Patient administration errors can still occur as a result of operator error during programming or incorrectentry of therapy parameters. The radiation emergency is still ongoing. The radiation guide tube can be removed from the device or patient (Inoue et al., 1996).

Table 1: Radioactive Loading for Remote afterloading machine

Radioactive sources	Used in	Reasons
^{60}Co	LDR, MDR, or HDR	longer half-lives and lower specific activities
^{137}Cs	LDR, MDR, or HDR	longer half-lives and lower specific activities
^{192}Ir		

2. Safety Design for Remote Afterloading

HDR remote afterloaders are intricate machines that include radioactive sources of extremely high activity (Scanderbeg et al., 2020). Serious mishaps might occur fast as a result of the high dosage rate and the short shirt treatment durations (Frenière, 2018). Each of these units has a number of safety features andoperational interlocks to stop errant source movement or to allow quick operator response in the event of a system failure. The 10 CFR Part 35.615 safety features are all included in brand-new installations, according to the manufacturers. Below is the safety features for remote afterloading.

2.1 Emergency Switches

There are several “EMERGENCY STOP” switches spread out in ideal locations that are simple to get to in case of emergency occurs. On the control panel, there is one switch marked“EMERGENCY OFF” or “EMERGENCY STOP”. On the top of the treatment head for the remote afterloader is another that button. The treatment room’s walls often include one or twoemergency switches installed by vendors. If treatment is started in the treatment room while someone other than the patient is there, that person has the option of stopping it and retractingthe sources by pushing that button.

2.2 Emergency Crank

All treatment units have an emergency crank to manually retract the source cable if thesource fails to retract regularly and the emergency motor also fails to reel in the source. To turn the crank, the operator must go into the area where the source is not shielded.

2.3 Door Interlock

The door cannot be opened to begin treatment due to interlock mechanisms. In the event that someone enters the treatment room without the operator's knowledge while treatment is in process, this safety feature protects the medical personnel from radiation exposure. The therapy ends when the door is opened. If a door is unintentionally opened whilethe therapy is being provided, the therapy is stopped and the source is returned to the safe. The treatment can continue where it left off by closing the door and pressing the "START" or "RESUME" button on the control panel.

2.4 Audio or Visual System

All (High-dynamic-range) HDR rooms must have a closed-circuit television system, shielded windows, or mirrors for patient observation, as well as a two-way audio system for patient communication.

2.5 Radiation Monitor and treatment on Indicator

When the source is not protected, three different separate mechanisms inform the staff. The treatment unit has one radiation detector, and when it detects radiation, it displays a warning on the control panel. A separate device alerts the operator and other staff members when the radioactive source escapes the safe. This device typically has displays inside and outside the treatment room and is mounted on the wall. When the source is revealed, a treatment indication outside the room—typically over the door—activates, likewise signaling that treatment is underway.

2.6 Backup Battery

The device has a backup battery to provide source retraction to its safety in the event of a power outage during the course of the treatment. With each change in the source, the batteries should be tested.

2.7 System Failure

The radioactive source must be removed from the patient right away if it won't retract afterbeing stopped, interrupted, turning the emergency off switch, or manually operating the steppermotor.

3. Equipment Selection and Patients

The choice of a particular remote afterloading device depends on the type and number of patients to be treated, the overall cost and available funding of the project, and the radiation oncologist's willingness to adopt new methods of patient care. In other words, if planning to replace manual brachytherapy with a remote afterloading procedure, a careful retrospective review of previous patient treatments over several years is recommended. gives a reasonable estimate. Example situation: A significant number of gynecological patients are often treated with a combination of interstitial vaginal implants combined with conventional intrauterine tubes. Such combination therapies cannot be administered in some low dose afterloading units designed for gynecologicalcare (Glenn et al. 1993).

3.1. Application in Brachytherapy

Brachytherapy is a type of radiation therapy in which a source of radiation is placed in or around the area to be treated. (Isnaini et al., 2019). This is a high-dose-rate, remote afterloading technique widely used in oncology today. Although brachytherapy had established itself as a highly effective method of cancer treatment, its use became dangerous by the mid-20th century as the perceived dangers of radiation to health care workers became apparent. it was done. The discovery of radiation source afterloading techniques will have a significant impact on the use of brachytherapy. The introduction of afterloading eliminated exposure and initiated a renaissance in brachytherapy (Jesse and Aronowitz, 2015).

Previously, 2D imaging techniques could be used to load radioactive Ir-192 into brachytherapy and manually reload empty surgically implanted tubes. In the 1980s, a newbrachytherapy approach was introduced to treat prostate cancer (Kemikler, 2019). Patients treated with temporary seeds inserted using a transperineal approach. Serious limitations such as the need for open incision, dosimetry problems, and poor results hindered the introduction of these techniques.The lack of specific antigen screening (for ideal patient selection) also contributes to the high recurrence rate. However, some important information was gleaned from these early seed transplanting approaches. Local control was better in patients with low-grade and early-stage cancer who received high-quality implants (Aronowitz et al., 2011).

Despite any type of remote afterloader, radiation control procedures include safety features, the facility's initial radiological evaluation and subsequent patient evaluations, routine precautions during normal use, precautions during source replacement, and emergencies. This includesprocedures and training (Palmer, 2014). In addition to the device safety features included in the plan, the treatment room safety implemented in future plans should also be considered. For example, a treatment room door sensor should be installed so that therapy is only performed when the door isclosed. When the door is opened, therapy is automatically interrupted and the emergency motor iswithdrawn from the source into storage. Apart from that, the dose needs to be reviewed and the actual quality improved. We need to improve the weight and dimensions of our equipment, as wellas improve the movement speed performance of the source (Lee, 2014).

4. Conclusion

In conclusion, this review focus on the safety design of remote afterloading machine. The staff who manage it, such as radiation oncologists, physicists, attending doctors, sourcecurators, nurses, and other allied health workers, benefit greatly from this machine's usage ofremote control to operate it from a distance. Although this remote afterloading machine hasits own benefit, it can cause very dangerous hazards if not handled perly. Because ofthe high dose rate and short treatment times, serious accidents can happen quickly. The safetydesign of the remote afterloading machine was created with respect to safety. It is because thesemachines contain very high-activity radioactive sources. Several safety considerations have been designed into the device to ensure proper operation. Today's remote afterloading offers significant advantages and improvements in radiation therapy, especially brachytherapy. The discovery of the afterloading technology of radioactive source givesa great impact on the use of brachytherapy. Despite all remote afterloading technology could offer,safety or radiation control towards the equipment, personnel, and patients involved still crucially need to be always supervised.

Acknowledgement

The authors would like to thank the Faculty of Applied Sciences and Technology for facilities provided that make the research possible.

References

Akiyama, H., Yoshida, K., Shimizutani, K., Yamazaki, H., Koizumi, M., Yoshioka, Y., Kakimoto, N., Murakami, Y., Furukawa, S., Ogawa, K. (2012) Dose reduction trial from 60 Gy in 10 fractions to 54 Gy in 9 fractions schedule in high-dose-rate interstitial brachytherapy for early oral tongue cancer**.** Journal of Radiation Research 53 (5), 722–726.

Armstrong JG. (2022). High Dose Rate Remote Afterloading Brachytherapy for Lung and Esophageal Cancer. Seminars in Radiation Oncology, 3(4). https://doi.org/10.1053/SRAO00300270

Aronowitz J. N., Grimard D. L. and Robison R. (2011). Precedence for prostate brachytherapy. Brachytherapy, 10(3):201–7.

Frenière N. (2018). COMP report: CPQR technical quality control guidelines for brachytherapy remote afterloaders. J Appl Clin Med Phys. 19(2), 39-43.

Glasgow, G. P., & Corrigan, K. W. (1995). Radiation Design and Control Features ofa Hospital Room for a Low Dose Rate Remote Afterloading Unit. Health Physics, 69(3), 415–419. https://doi.org/10.1097/00004032-199509000-00017

Glenn P. Glasgow, J. Daniel Bourland, Perry W. Grigsby, Jerome A. Meli, Keith A. Weaver. (1993). Remote Afterloading Technology, A Report of AAPM No. 41, 1-116.

Grigsby, P. W., Slessinger, E. D., Teague, S. P., Williamson, J. F., & Perez, C. A. (1995). Clinical evaluation of an interstitial remote afterloading device for multichannelintracavitary irradiation. International Journal of Radiation Oncology*Biology*Physics, 31(4), 875–881. https://doi.org/10.1016/0360-3016(94)00539-7

Heinrich Seegenschmiedt M., Gerhard G. Grabenbauer, Michael Lotter, Reinhold G. Muller, Rainer Fietkau and Rolf Sauer. Clinical Experience Qith a New remote Afterloading System for Low Dose Rate Brachytherapy. (1994). Endocurietherapy/Hyperthermia Oncology 10, 237-244Isnaini, I., Triyanto, J., & Sukandar. (2019). The safety aspect design for remote afterloading high dose rate brachytherapy Ir-192. AIP Conference Proceedings. https://doi.org/10.1063/1.5135543

Inoue T, Inoue T, Teshima T, Murayama S, Shimizutani K, Fuchihata H. and Furukawa S. (1996). Phase III trial of high vs. low dose rate interstitial radiotherapy for early oral tongue cancer, Int

J Radiat Oncol Biol Phys, 2001, vol. 51, 171-175.

Isnaini, I., Triyanto, J. and Sukandar (2019). The safety aspect design for remoteafterloading high dose rate brachytherapy Ir-192, AIP Conference Proceedings 2180, 020034.

Jesse N. and Aronowitz M. D. (2015). Afterloading: The Technique That Rescued Brachytherapy, International Journal of Radiation Oncology*Biology*Physics, 92(3), 479-487

Kemikler, G. (2019). History of Brachytherapy. Turkish Journal of Oncology, 34 (Supp 1), 1–10.

Lee CD. (2014). Recent developments and best practice in brachytherapy treatment planning. Br J Radiol. 87(1041), 20140146

Nastya Makarova. (2020). Handbook of radiotherapy physics. Academia.edu.

Palmer AL. (2014). BJR brachytherapy dosimetry special feature. Br J Radiol. 87(1041), 20140506

Scanderbeg, D. J., Yashar, C., Ouhib, Z., Jhingran, A., and Einck, J. (2020). Development, implementation, and associated challenges of a new HDR brachytherapy program. Brachytherapy, 19(6), 874–880.

Tačev, T., Grigorov, G., Papírek, T., & Kolařík, V. (2003). Remote Afterloading for Neutron Brachytherapy Using Californium-252. Strahlentherapie Und Onkologie, 179(2), 113–117. https://doi.org/10.1007/s00066-003-1006-3

Tortorelli, J. P., Simion, G. P., & Kozlowski, S. D. (1994). A compilation of current regulations, standards and guidelines in remote afterloading brachytherapy. https://doi.org/10.2172/10196713

Van Limbergen, E., Saw, C.B. (2013). Afterloading Technique. In: Brady, L.W., Yaeger, T.E. (eds) Encyclopedia of Radiation Oncology. Springer, Berlin, Heidelberg.

Verma, R., Jain, G. K., & Chougule, A. (2020). Implementation of safety and securitystandards for high dose rate brachytherapy sealed radioactive source used in a medicalradiation facility. Radiation Medicine and Protection, 1(4), 166–170. https://doi.org/10.1016/j.radmp.2020.11.004