Technical Note

Original paper

COMIRI – COMplexity Index of interventional Radiotherapy (brachytherapy) Implants: assessment of procedures based on type, equipment, and team

Bruno Fionda, MD[1], Elisa Placidi, Med Phys, PhD[2], Valentina Lancellotta, MD[1], Enrico Rosa, Med Phys[2,3], Martina De Angeli, MD[1], Piotr Wojcieszek, MD, PhD[4], Frank-André Siebert, Med Phys, PhD[5], Prof. Marco De Spirito, Med Phys, PhD[2,6], Prof. Maria Antonietta Gambacorta, MD, PhD[6,7], Luca Tagliaferri, MD, PhD[1,6]

[1]UOC Degenze di Radioterapia Oncologica, Dipartimento di Diagnostica per Immagini e Radioterapia Oncologica, Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome, Italy, [2]UOC Fisica per le Scienze della Vita, Dipartimento di Diagnostica per Immagini e Radioterapia Oncologica, Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome, Italy, [3]eCampus University, Novedrate (CO), Italy, [4]Brachytherapy Department, Maria Skłodowska-Curie National Research Institute of Oncology Gliwice Branch, Wybrzeże Armii Krajowej, Gliwice, Poland, [5]Clinic of Radiotherapy, University Hospital of Schleswig-Holstein, Campus Kiel, Germany, [6]Università Cattolica del Sacro Cuore, Rome, Italy, [7]UOC Servizio di Radioterapia Oncologica, Dipartimento di Diagnostica per Immagini e Radioterapia Oncologica, Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome, Italy

The research was conducted in cooperation with the above-mentioned centers.

Abstract

Historically, several classification systems have been used for brachytherapy, and they were based on the type of clinical purpose, type of implant and timing of the implant, dose-rate, and type of loading for treatment delivery. However, over the last decades, there have been some major technological advancements, including the introduction of image-guidance and possibility to modulate the dose delivered, which have led several authors (in order to highlight the differences between old technique and new approach) to label it in a different way by replacing "brachytherapy" with "interventional radiotherapy". Modern interventional procedures involve several key aspects, which contribute to the complexity of implant phase, such as implant type, imaging used during the procedure, and role of multi-disciplinary team in operating room. By assigning scores to these procedural elements, it is possible to classify the procedure's complexity using a COMIRI classification (COMplexity Index of interventional Radiotherapy Implants). The aim of the COMIRI classification system is to appropriately highlight the need for suitable resources based on the complexity level of different procedures in terms of personnel expertise, equipment availability, and multi-disciplinary teamwork.

J Contemp Brachytherapy 2024; 16, 4: 306–309
DOI: https://doi.org/10.5114/jcb.2024.143223

Key words: interventional oncology, interventional radiotherapy, brachytherapy.

Interventional radiotherapy (IRT, brachytherapy) is a radiotherapy technique, in which radioactive sources are placed directly into or near the tumor site. IRT procedures are widely used in modern oncology, because they allow for treating different anatomical locations while delivering high doses and sparing the surrounding organs at risk [1]. Moreover, IRT is a procedure that requires several phases, which could be briefly classified as the clinical indication, implant, treatment planning, and delivery. Historically, several classification systems have been used for IRT, and they were based on the type of clinical purpose, type of implant and timing of the implant, dose-rate, and type of loading for treatment delivery.

According to IRT clinical indication, it is possible to identify radical IRT when: 1. The aim of treatment is to cure, and IRT is delivered as the only treatment modality or as a boost to external beam radiotherapy [2]; 2. Post-operative purpose when IRT is employed after a surgical intervention to improve local control [3]; and 3. Palliative intent when the only reasonable clinical result expected is a reduction of clinical symptoms [4]. With regard to the type of implant, different types of IRT approaches can be

Address for correspondence: Elisa Placidi, PhD, Medical Physicist, UOC Fisica per le Scienze della Vita, Dipartimento di Diagnostica per Immagini e Radioterapia Oncologica, Fondazione Policlinico Universitario A. Gemelli, IRCCS, 00168, Rome, Italy, phone: +39-0630154997, ✉ e-mail: elisa.placidi@policlinicogemelli.it

Received: 06.06.2024
Accepted: 03.09.2024
Published: 20.09.2024

distinguished, including contact [5], intra-cavitary [6], intra-luminal [7], and interstitial [8] techniques. Another way to classify the types of implants is to divide them into permanent or temporary implants [9].

In terms of dose-rate, low-dose-rate (LDR) [10], pulsed-dose-rate (PDR) [11], or high-dose-rate (HDR) [12] can be classified. Specifically, LDR is defined as a dose of 0.4-2.0 Gray (Gy)/h, and HDR is identified as a dose of > 12 Gy/h [13], with typical irradiation distance.

It is also important to emphasize that modern IRT mostly relies on remote afterloading units, which allow for significant decrease of radiation exposure on interventional radiation oncologists and radiation therapists [14, 15]. Another aspect to consider when classifying different IRT techniques is the overall number of catheters used to deliver the dose. In this regard, there are mono-catheter implants (for example, in adjuvant vaginal applicators where only the central channel is active) [7] or multi-catheter implants [8]. Finally, the role of anesthesiologist during the procedure is of paramount importance, since various procedures require local anesthesia (including spinal anesthesia), analgosedation, or general anesthesia [16].

In Table 1, the different classification systems are summarized according to phases of IRT process they are based on.

It is worth to underline that IRT has been recognized as a relevant part of modern oncology [17, 18], and is currently the subject of a huge interest, being used after a slow but inevitable decline in previous years [19]. The main reasons for such renewed interest in IRT are recent technological innovations, which have dramatically changed the clinical practice [20].

The first revolution occurred with the introduction of 3D image guidance for simulation and treatment planning [21]. The second point of paramount relevance is the launching of intensity-modulated external beam radiotherapy with dedicated 3D treatment planning systems in clinical practice, allowing for dose escalation and organ-sparing during EBRT [22]. These two technological advancements enabled discussions about image-guided and intensity-modulated IRT, respectively. To highlight the differences between the old technique and the new approach, some authors used a different naming, replacing "brachytherapy" with "interventional radiotherapy".

All the afore-mentioned classification systems are useful and currently implemented in the clinical practice. However, none of them consider the varying degree of complexity that characterizes interventional procedures.

Specifically, IRT tools and strategies are continuously changing and updating. On the one hand, the role of image guidance is gaining more and more relevance [23], and on the other hand, the close and collaborative role of surgeons during some IRT procedures allows for safer and higher quality implants [24].

There are several aspects of interventional procedures regarding the complexity of implant phase, including the type of implant, imaging used during the procedure, and the role of multi-disciplinary team in operating room, as summarized in Table 1. Therefore, the implant complexity results from the combination of three different aspects:

1. Type: As mentioned before, the type of implant may be contact, intra-cavitary, intra-luminal, or interstitial. The clinical and technical difficulties in the management of different types of implants are directly correlated with the expertise of interventional radiation oncologist. In addition, implants could be either based on single-catheter or multiple catheters.
2. Equipment: The imaging used during implantation can be visual only (or requiring specific expertise, such as dermoscopy), and can rely on radiography, ultrasound, or CT, which are manageable by the radiation oncologist. Moreover, in selected cases, the imagining can require endoscopy (performed directly by IRT physician in selected centers only) or MRI.
3. Team: This point is related to the need of a multi-disciplinary team in the operating room that, in addition to the interventional radiation oncologist, can comprise an anesthesiologist or, in certain circumstances, additional specialists, such as the surgeon to manage possible acute intra-operative complications, or medical physicist to support the implant procedure.

Based on the different procedural aspects, a system can be proposed to classify the complexity of procedures according to the overall score of the above-mentioned aspects of interventional procedures (Table 2), including the type of implant, primary imaging used during implantation, number of catheters, participation of an anesthesiologist, and multi-disciplinary team involvement.

In Table 3, the scores of various typical procedures in commonly treated sites with four different degrees of complexity according to the scores with the following intervals, are presented: low (≤ 5), moderate (between 6 and 8), high (between 9 and 10), and very high (≥ 11). However, some clinics might use different approaches with diverse overall scores obtained for the same procedures.

It is absolutely fundamental to emphasize that the current proposal aimed at adequately framing a specific phase of IRT procedure, which is the implant. However, no association should be made between the complexity of implant and the complexity of subsequent phases. In fact, even contact skin radiotherapy that has a relatively low complexity implant is characterized by the same level of complexity regarding subsequent phases, relies on an accurate patient diagnosis, and both on imaging [25] and intensity modulation [26], in order to prevent toxicities [27].

Table 1. Different classification systems used in interventional radiotherapy (brachytherapy)

Phase	System
Indication	Radical, post-operative, palliative
Implant type	Contact, intra-cavitary, intra-luminal, interstitial
Implant timing	Permanent, temporary
Dose-rate	LDR, PDR, HDR
Simulation	RX, US, CT, MRI
Loading	Manual loading, remote afterloading
Number of catheters	Mono-catheter, multi-catheter
Anesthesiologist	Yes, No

Table 2. Different scores assigned according to the COMIRI system (scores are given in brackets)

Type of implant	Contact (1)	Intracavitary (2)	Intraluminal (3)	Interstitial (4)
Primary imaging used during implant	Visual/cognitive (1)	RX (2)	US/CT (3)	Endoscopy/MRI (4)
Involvement of anesthesiologist	No (0)	Local/analgosedation (1)		General (2)
Number of catheters	Mono (1)		Multiple (2)	
Interdisciplinary involvement during implant	No (0)		Yes (2)	

RX – radiography, US – ultrasound, CT – computed tomography, MRI – magnetic resonance imaging

Table 3. Complexity levels of implants in different anatomical sites

	Type of implant	Imaging during implant	Anesthesiologist	No. of catheters	Multi-disciplinary involvement during implant	Overall score	Complexity
Vaginal cuff	2	1	0	1	0	4	Low
Skin[a]	1	1	0	2	0	4	
Cervix[a]	2	3	0	2	0	7	Moderate
Skin[b]	4	1	1	2	0	8	
Cervix[b]	4	3	1	2	0	10	High
Anal canal	4	3	1	2	0	10	
Breast	4	3	1	2	0	10	
H&N[c]	4	1	2	2	2[d]	11	Very high
Uveal melanoma	4	3	2	2[e]	2[f]	13	
Prostate	4	3	2	2	2[g]	13	

[a] Non-interstitial implant, [b] Interstitial implant, [c] Different anatomical locations, such as tongue and nose vestibule, [d] ENT surgeon, [e] Number of radioactive seeds for a plaque, [f] Ophthalmologist, [g] Medical physicist

There is a disparity in terms of access to IRT across different countries, and several domains should be empowered to foster the spread of this effective technique, including the clinical practice, education, research, and communication [28]. It is desirable that the correct understanding of the implant complexity can lead to changes in reimbursement systems, which may improve sustainability of IRT [29].

In addition, there are several dose calculation methods used in IRT. TG-43 relies on standardized data assuming a homogeneous medium, such as water, and is clinically validated. In contrast, TG-186 uses advanced algorithms to account for tissue heterogeneities and applicator characteristics, offering more accurate and personalized dose distributions. While TG-186 is not yet fully clinically validated, it should be further implemented to enhance dosimetric accuracy in brachytherapy [30]. In particular, the addition of the COMIRI classification system should adequately indicate the need for suitable resources according to the level of complexity for different IRT procedures in terms of personnel expertise, equipment availability, and multi-disciplinary teamwork.

Funding

This research received no external funding.

Disclosures

Approval of the Bioethics Committee was not required.
The authors declare no conflict of interest.

References

1. Chargari C, Deutsch E, Blanchard P et al. Brachytherapy: An overview for clinicians. *CA Cancer J Clin* 2019; 69: 386-401.
2. Tagliaferri L, Carra N, Lancellotta V et al. Interventional radiotherapy as exclusive treatment for primary nasal vestibule cancer: single-institution experience. *J Contemp Brachytherapy* 2020; 12: 413-419.
3. Harkenrider MM, Block AM, Alektiar KM et al. American Brachytherapy Task Group Report: Adjuvant vaginal brachytherapy for early-stage endometrial cancer: A comprehensive review. *Brachytherapy* 2017; 16: 95-108.
4. Jooya A, Talla K, Wei R et al. Systematic review of brachytherapy for symptom palliation. *Brachytherapy* 2022; 21: 912-932.
5. Likhacheva AO, Devlin PM, Shirvani SM et al. Skin surface brachytherapy: A survey of contemporary practice patterns. *Brachytherapy* 2017; 16: 223-229.
6. Fokdal L, Sturdza A, Mazeron R et al. Image guided adaptive brachytherapy with combined intracavitary and interstitial technique improves the therapeutic ratio in locally advanced cervical cancer: Analysis from the retroEMBRACE study. *Radiother Oncol* 2016; 120: 434-440.
7. Wortman BG, Astreinidou E, Laman MS et al.; PORTEC Study Group. Brachytherapy quality assurance in the PORTEC-4a trial for molecular-integrated risk profile guided adjuvant treatment of endometrial cancer. *Radiother Oncol* 2021; 155: 160-166.
8. Strnad V, Major T, Polgar C et al. ESTRO-ACROP guideline: Interstitial multi-catheter breast brachytherapy as Accelerated Partial Breast Irradiation alone or as boost – GEC-ESTRO Breast Cancer Working Group practical recommendations. *Radiother Oncol* 2018; 128: 411-420.
9. Skowronek J. Current status of brachytherapy in cancer treatment – short overview. *J Contemp Brachytherapy* 2017; 9: 581-589.

10. Stish BJ, Davis BJ, Mynderse LA et al. Low dose rate prostate brachytherapy. *Transl Androl Urol* 2018; 7: 341-356.
11. Pieters BR, Geijsen ED, Koedooder K et al. Treatment results of PDR brachytherapy combined with external beam radiotherapy in 106 patients with intermediate- to high-risk prostate cancer. *Int J Radiat Oncol Biol Phys* 2011; 79: 1037-1042.
12. Hoskin PJ, Colombo A, Henry A et al. GEC/ESTRO recommendations on high dose rate afterloading brachytherapy for localised prostate cancer: an update. *Radiother Oncol* 2013; 107: 325-332.
13. International Commission on Radiation Units and Measurements (ICRU) Dose and volume specifications for reporting intracavitary therapy in gynecology. Bethesda, MD: ICRU, 1985.
14. Whelan TJ, Aldrich JE, Voruganti SM et al. A comparison of manual and remote afterloading in the treatment of carcinoma of the cervix: increasing dose rate with a flexible applicator. *Clin Oncol (R Coll Radiol)* 1992; 4: 294-298.
15. Aronowitz JN. Afterloading: The technique that rescued brachytherapy. *Int J Radiat Oncol Biol Phys* 2015; 92: 479-487.
16. Roessler B, Six LM, Gustorff B. Anaesthesia for brachytherapy. *Curr Opin Anaesthesiol* 2008; 21: 514-518.
17. Tree AC, Harding V, Bhangu A et al. The need for multidisciplinarity in specialist training to optimize future patient care. *Nat Rev Clin Oncol* 2017; 14: 508-517.
18. Kovács G, Tagliaferri L, Valentini V. Is an Interventional Oncology Center an advantage in the service of cancer patients or in the education? The Gemelli Hospital and INTERACTS experience. *J Contemp Brachytherapy* 2017; 9: 497-498.
19. Williams VM, Kahn JM, Thaker NG et al. The case for brachytherapy: Why it deserves a renaissance. *Adv Radiat Oncol* 2021; 6: 100605.
20. Kovács G. Modern head and neck brachytherapy: from radium towards intensity modulated interventional brachytherapy. *J Contemp Brachytherapy* 2015; 6: 404-416.
21. Sturdza A, Pötter R, Fokdal LU et al. Image guided brachytherapy in locally advanced cervical cancer: Improved pelvic control and survival in RetroEMBRACE, a multicenter cohort study. *Radiother Oncol* 2016; 120: 428-433.
22. Callaghan CM, Adams Q, Flynn RT et al. Systematic review of intensity-modulated brachytherapy (IMBT): static and dynamic techniques. *Int J Radiat Oncol Biol Phys* 2019; 105: 206-221.
23. Berger D, Van Dyk S, Beaulieu L et al. Modern tools for modern brachytherapy. *Clin Oncol (R Coll Radiol)* 2023; 35: e453-e468.
24. Volz S, Kalousis K, Song JI et al. Brachytherapy in soft tissue tumours: an interdisciplinary challenge! *Hell J Nucl Med* 2017; 20 Suppl: 163.
25. Yu L, Oh C, Shea CR. The treatment of non-melanoma skin cancer with image-guided superficial radiation therapy: An analysis of 2917 invasive and in situ keratinocytic carcinoma lesions. *Oncol Ther* 2021; 9: 153-166.
26. Fionda B, Placidi E, Rosa E et al. Multilayer intensity modulated contact interventional radiotherapy (brachytherapy): Stretching the therapeutic window in skin cancer. *J Contemp Brachytherapy* 2023; 15: 220-223.
27. Rembielak A. Complex and prolonged skin toxicity after superficial brachytherapy for basal cell carcinoma on the lower leg. *J Contemp Brachytherapy* 2020; 12: 406-411.
28. Tagliaferri L, Vavassori A, Lancellotta V et al. Can brachytherapy be properly considered in the clinical practice? Trilogy project: The vision of the AIRO (Italian Association of Radiotherapy and Clinical Oncology) Interventional Radiotherapy study group. *J Contemp Brachytherapy* 2020; 12: 84-89.
29. Swain M, Budrukkar A, Rembielak A et al. Challenges in the sustainability of brachytherapy service in contemporary radiotherapy. *Clin Oncol (R Coll Radiol)* 2023; 35: 489-496.
30. Placidi E, Fionda B, Rosa E et al. Dosimetric impact of applying a model-based dose calculation algorithm for skin cancer brachytherapy (interventional radiotherapy). *J Contemp Brachytherapy* 2023; 15: 448-452.