Title

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Journal

International Journal of Radiation Oncology • Biology • Physics, 116(2)

ISSN

0360-3016

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Publication Date

2023-06-01

DOI

10.1016/j.ijrobp.2022.11.042

Peer reviewed

HHS Public Access

Author manuscript

Int J Radiat Oncol Biol Phys. Author manuscript; available in PMC 2024 June 01.

Published in final edited form as:

Int J Radiat Oncol Biol Phys. 2023 June 01; 116(2): 439–447. doi:10.1016/j.ijrobp.2022.11.042.

Quality Assurance in Clinical Trials Requiring Radiotherapy in sub-Saharan Africa

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Abstract

Purpose: Given the increasing availability of radiotherapy in sub-Saharan Africa, clinical trials that include radiotherapy are likely to grow. Ensuring appropriate delivery of radiotherapy through rigorous quality assurance is an important component of clinical trial execution. We reviewed the process for credentialing radiotherapy sites and radiotherapy quality assurance through the

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Data sharing statement: Data is available upon reasonable written request.

Imaging and Radiation Oncology Core (IROC) Houston Quality Assurance Center for AMC-081, a multicenter study of cisplatin and radiotherapy for women with locally advanced cervical cancer living with HIV, conducted by the AIDS Malignancy Consortium at 2 sites in South Africa and Zimbabwe.

Methods: Women living with HIV with newly diagnosed stage IB2, IIA (>4 cm), IIB-IVA cervical carcinoma (per 2009 FIGO) were enrolled on AMC-081. They received 3D conformal external-beam radiotherapy (EBRT) to the pelvis (41.4–45 Gy) using a linear accelerator, high dose rate brachytherapy (6–9 Gy to point A with each fraction and up to 4 fractions), and concurrent weekly cisplatin (40 mg/m^2). IROC reviewed EBRT and brachytherapy quality assurance records after treatment.

Results: All of the 38 women enrolled on AMC-081 received +/− 5% of the protocol-specified prescribed dose of EBRT. Geometry of brachytherapy applicator placement was scored as per protocol in all implants. Doses to points A and B, ICRU bladder, or ICRU rectum required correction by IROC in >50% of the implants. In the final evaluation, 58% of participants (n=22) were treated per protocol, 40% (n=15) had minor protocol deviations, and 3% (n=1) had major protocol deviations. No records were received within 60 days of treatment completion as requested in the protocol.

Conclusion: Major radiotherapy deviations were low, but timely submission of radiotherapy data did not occur. Future studies, especially those that include specialized radiotherapy techniques such as stereotactic or intensity-modulated radiotherapy, will require pathways to ensure timely and adequate quality assurance.

Keywords

HIV; cervical cancer; sub-Saharan Africa; radiotherapy; quality assurance

Introduction

Cervical cancer is the fourth most common cancer in women in the world, with approximately 604,000 new cases reported by GLOBOCAN in 2020 and an estimated 342,000 deaths (1). Invasive cervical cancer is the most common cancer in women in low-resource countries, where screening for pre-invasive lesions and prevention programs are limited. For women with locally advanced cervical cancer, radiotherapy concomitant with chemotherapy is the standard of care and offers high survival rates even in those who present with bulky disease.(2) To achieve the World Health Organization goal of most women obtaining timely access to cervical cancer treatment by 2030,(3) it is critical to focus on not only on the delivery but also the quality of radiation therapy to ensure high survival rates.

In sub-Saharan Africa in particular, because of the coincident burden of the human immunodeficiency virus (HIV), a large proportion of women with cervical cancer are also living with HIV.(4) As such, the AIDS Malignancy Consortium (AMC), a National Cancer Institute (NCI)-supported multicenter clinical trials group, initiated AMC-081, a prospective study of concurrent cisplatin and radiotherapy for women living with HIV (WLWH) and locally advanced cervical cancer in sub-Saharan Africa.(5) This was the first

AMC-sponsored study in Africa that included radiotherapy. Its primary results have been published elsewhere.(5) Briefly, 38 eligible WLWH initiated chemoradiotherapy and 31 (82%) completed therapy as prescribed while maintaining high adherence to anti-retroviral therapy. The 1-year progression-free survival rate was 76.3%. Overall, treatment was considered well-tolerated among WLWH, with the incidence and types of serious adverse events similar to historical data from women who were HIV-negative.(6) These results are relevant not only to patients with cervical cancer in sub-Saharan Africa but also to WLWH who have cervical cancer globally. The Cervical Cancer Research Network, a subsidiary of the Gynecologic Cancer Intergroup, previously demonstrated the feasibility of conducting cervical cancer clinical trials in low-to-middle-income (LMIC) countries (7) such as India, Vietnam, and Thailand, but to our knowledge, multicenter studies that include radiotherapy have been limited in sub-Saharan Africa.

A critical component of appropriate clinical trial execution and robust data acquisition is ensuring that participating institutions can treat patients according to protocol stipulations and provide quality assurance for the radiotherapy components. To this end, the Imaging and Radiation Oncology Core (IROC) Houston Quality Assurance Center developed and implemented credentialing processes for numerous study groups for clinical trials that include radiotherapy as a treatment component. Typically, IROC credentialing involves demonstration of adequate knowledge of the protocol, evaluation of the treatment planning system, ensuring that the appropriate radiotherapy quality assurance procedures are followed including confirmation that the linear accelerator's output, per energy, is within acceptable criteria. This is accomplished through a comprehensive set of questionnaires, test cases or benchmarks, review of treatment data and procedures, and irradiation of dosimeters. Approval may be given for an institution, specific personnel, or both.

The paucity of randomized clinical trials conducted in LMICs that include radiotherapy has recently been highlighted (8,9); one of the challenges is ensuring that radiotherapy delivery is appropriate and quality assurance is consistent across centers. The purpose of this manuscript is to review the process of radiotherapy credentialing, site initiation, and post-treatment radiotherapy quality assurance review for AMC-081, a cervical cancer study conducted in sub-Saharan Africa. This analysis is intended to share our experience, and the results are expected to serve as a guide for future AMC studies that include radiotherapy among people living with HIV and cancer in LMIC. The processes of quality control that we report herein can be used to optimize patient outcomes in future studies, particularly as more complex radiotherapeutic techniques such as intensity-modulated radiotherapy (IMRT) or stereotactic body radiotherapy may be included in multicenter studies in settings where rigorous quality assurance methods have not been as widely implemented.

Methods

AMC sites in sub-Saharan Africa with radiotherapy capability were invited to participate in AMC-081, titled "Feasibility Study of Safety, Toxicity, and Compliance of Concomitant Chemoradiotherapy for HIV-Associated Locally-Advanced Cervical Cancer." The process for overall credentialing for AMC sub-Saharan Africa core sites has been described elsewhere.(10) Participating sites were required to have CT-based treatment simulation,

external-beam radiotherapy with linear accelerator, brachytherapy, and a pharmacy area with a biosafety cabinet and hood to safely prepare intravenous chemotherapy. At the time this study was conducted (2014–2016), only two of the four African AMC sites that were funded at that time met these criteria—Parirenyatwa Hospital in Harare, Zimbabwe and Charlotte Maxeke Johannesburg Academic Hospital in Johannesburg, South Africa - and both participated in the trial. The process for site credentialling, submission, and review of radiotherapy documentation is outlined in Fig. 1.

Clinical trial

Details of AMC-081 including participant characteristics, eligibility and the overall treatment protocol are published elsewhere.(5) Briefly, women living with HIV with FIGO stage IB2, IIA (>4 cm), IIB-IVA cervical cancer by the 2009 staging system(11) with pathologically confirmed carcinoma, previously untreated, were eligible. Participants received a combination of external beam radiotherapy, brachytherapy, and concurrent cisplatin chemotherapy. All participants underwent CT simulation and pelvic external beam radiotherapy (prescribed dose of 41.4–45 Gy in 1.8-Gy fractions) followed by brachytherapy as outlined below. Chemotherapy consisted of weekly cisplatin (40 mg/m^2).

Radiotherapy credentialing

Sites participating in AMC-081 were required to successfully complete the IROC Houston's credentialing process for institutional approval before activating the study as outlined in Table 1. The purpose of this process was to verify that institutions could achieve an accuracy within +/− 5% in measuring the calibrated reference beam output of their external-beam therapy units.(12) In addition, each study participant's records were reviewed by IROC Houston after treatment to verify that each participant had received a radiation therapy dose to within +/− 5% of the prescribed external-beam dose and +/− 15% of the intracavity brachytherapy boost (dose to point A).(13) The protocol required sites to submit records within 60 days after treatment completion.

To verify that these credentialing standards were met, each site had to submit the items listed in Table 1 for review by an IROC physicist. A successful review is one where the institution has met the guidelines of the American Association of Physicists in Medicine (AAPM) for quality assurance procedures (AAPM TG-40 and TG-43), the dose delivered for each photon energy for all of their linear accelerators were within ±5% of the expected dose (AAPM TG-51, IAEA TRS 277 or TRS 398), and the standards lab (SSDL or ADCL) certificates for their ionization chamber, brachytherapy chamber and electrometers, used to determine reference beam output of source assay, were valid and current.

A successful review led to a letter of approval sent to the study group and site stating that all criteria had been met for radiotherapy credentialing. Other processes for site selection and credentialing of sub-Saharan African sites as part of the AMC are described elsewhere.(10) Approvals from institutional review boards and national regulatory authorities were also obtained to enroll participants on AMC-081. In addition, hard copies of each participant's radiotherapy records were submitted via courier to IROC (in Houston, TX) for dosimetry review, as shown in Table 2.

External beam radiotherapy

All participants underwent CT simulation for treatment planning and treatment on a linear accelerator. External beam radiotherapy doses were recalculated by IROC Houston, and the absorbed dose to the AMC point of calculation(s) was verified as being within +/− 5% for external beam and +/−15% for brachytherapy. Recalculations were done using several methods: the IROC Houston's own dose calculation programs, the optically stimulated luminescence dosimeter (OSLD) results from IROC's OSLD monitoring program, and IROC's standard data set. The standard data set is a compilation of the characteristics of all the beams measured by IROC Houston for each type of make, model, and energy of a machine. If the IROC Houston's calculated dose agreed with the institution's reported dose, then the institution's reported dose was compared with the protocol-required dose to record compliance. If the IROC Houston's calculated dose did not agree with the institution's reported dose, then the IROC Houston's calculated dose was reported as the dose for the participant and compared with the required protocol dose. This review process also verified that no errors in transcription or reporting had been made. Overall treatment time was reviewed, reported, and compared with protocol stipulations.

Neither IMRT nor dose inhomogeneity corrections were allowed on this study. The protocol required use of a four-field box technique with parallel opposed anteroposterior and posteroanterior fields and two opposing lateral fields. The dose was calculated at the intersection of the axes of the four-field box. Participants could receive an external beam parametrial boost at the discretion of the treating radiation oncologist. The boost dose could range from 5.4 Gy to 9.0 Gy, given in 3–5 fractions, based on the extent of parametrial involvement. The prescription point was at the center of the unblocked portion of the field. A discrepancy in dose (from that specified by the protocol) of 6% to 10% was considered a minor deviation and a discrepancy of >10% was considered a major deviation from the protocol.

Brachytherapy

After the completion of whole-pelvic radiation therapy, the protocol stipulated that the participants could receive either low-dose-rate (LDR) brachytherapy or high-dose-rate (HDR) brachytherapy. As both participating institutions used only HDR brachytherapy, only HDR brachytherapy prescription doses are discussed below.

Sites were required to report the dose to points A and B and to the bladder and rectal points as defined by the International Commission on Radiation Units and Measurements (ICRU), (13) which were also defined, with diagrams, in the protocol. The protocol prescription for HDR brachytherapy was to deliver 6–9 Gy to point A with each brachytherapy fraction. Up to four HDR implants could be given, with the total HDR dose ranging from 18 to 28 Gy. Either cobalt-60 or Iridium-192 could be used for HDR; only medical radiation brachytherapy sources listed on the American Association of Physicists in Medicine source registry (http://irochouston.mdanderson.org/RPC/BrachySeeds/Source_Registry.htm) were allowed to be used for this protocol. The protocol-recommended dose limit to the rectum was 4.1–6.1 Gy for each 6- to 9-Gy HDR fraction (68% of the prescribed dose to point A),

and the dose to the bladder was 4.6–6.9 Gy for each 6- to 9-Gy HDR fraction (77% of the prescribed dose to point A).

Sites were required to submit complete brachytherapy treatment plans, including source strengths, source loading, and total treatment time, for each insertion. Sites using HDR brachytherapy had to submit dwell positions, dwell times, source activities, orthogonal films (Fig. 2) and a Gynecological Brachytherapy Protocol Compliance form that provided all other information needed for brachytherapy reconstruction. IROC Houston produced independent reconstructions of each implant and verified that the doses reported were those required by the protocol. IROC Houston also checked for reporting errors and transcription errors. Total treatment time was also verified, compared with that specified in the protocol, and reported to the AMC. If IROC Houston disagreed with the reported dose, then IROC Houston's dose was used for the analysis.

Results

The two institutions that participated in this protocol met the outlined criteria. Demographics and other characteristics of each enrolled participant have been described elsewhere.(5) Radiotherapy protocol adherence is outlined in Table 3.

External beam radiotherapy

Each of the 38 participants entered on AMC-081 received an external beam dose to the pelvis in the range of 41.4–45 Gy in 23–25 fractions. IROC Houston's independent recalculations showed that all reviewed participants on the protocol had received +/− 5% of the prescribed dose at the defined point of calculation. Six participants received a parametrial boost at the discretion of the treating physician. For these participants, independent recalculations by IROC Houston verified that these doses were also within the +/− 5% allowed by IROC Houston standards and the protocol. IROC Houston found that all external beam points of calculation were within acceptable criteria.

Brachytherapy

Each participant underwent 3 insertions of HDR brachytherapy at a dose per fraction of either 7 Gy or 8 Gy. The median total EQD2 (equivalent dose in 2-Gy fractions) to point A was 74.1 Gy (range 74.1–80.3 Gy). The median ICRU bladder point dose was 54.4 Gy (range 46–84 Gy). The median ICRU rectal point dose was 65.9 Gy (range 55.5–99.3 Gy). IROC Houston found that in 120 implants with available point A dose data, 14% (N=17) had a point A dose that was >15% lower than the point A dose calculated by IROC and in 0.8% (N=1), the point A dose was >15% higher than the IROC calculated point A dose. The errors were related to definition of the location of the cervical os (N=11), prescription point (N=2), and unknown in two implants. For the 58 implants where point B doses were calculated by the site, IROC Houston found discrepancies in reported doses to point B related to incorrect definition of point B in 57.6% (N=34) of implants. Point B doses were >15% higher than IROC calculated dose in 31% (N=18) of implants and >15% lower than IROC calculated dose in 27.5% (N=16). Site reported doses for the ICRU bladder point was available for 92 implants. Incorrect definition of the ICRU bladder point was observed in 54 implants

resulting in a >15% higher ICRU bladder point dose vs calculated dose by IROC in 33% (N=31) of implants and a lower ICRU bladder point dose in 25% (N=23) of the implants. In 108 implants where ICRU rectal point doses were available, dose discrepancies were noted by IROC in 66% (N=72) of implants. Reported doses were >15% higher than IROC in 18.5% (N=20) implants and >15% lower in 48% (N=52) of implants and related to incorrect definition/location of the ICRU rectal point in all cases.

Summary of radiation oncologist review

Quality control of external beam fields and brachytherapy applicator placement (Fig. 2) was reviewed at the completion of all therapy by a radiation oncologist (MG) for adherence to radiotherapy specifications outlined in the protocol and described in Table 3. Overall, the total tumor dose was within the protocol specifications for 92% of participants (n=35), and 81% (n=30) completed therapy within 56 days. Geometry of applicator placement and packing was scored as per protocol in all implants. In the final treatment evaluation, 58% of participants (n=22) were treated per protocol, 40% (n=15) had minor protocol deviations, and 3% (n=1) had major protocol deviations. Treatment was delayed for 11 participants because of holidays (n=2), machine breakdown (n=1), technical issues (n=1), neutropenia (n=1), and other toxicity (n=6).

Treatment-site perspectives

Clinicians at the treatment sites found the radiotherapy credentialing process to be straightforward, and both sites were certified on their first attempt. Both sites successfully delivered radiation as required by the protocol, but challenges were experienced with timely and complete data submission. All files were sent to Emmes Company located in Rockville, MD (the responsible clinical research organization) as hard copies because of government regulations, which prevented submitting hard copies of data potentially containing Protected Health Information and communications directly from the site to IROC. All submissions were then forwarded from Emmes to IROC. All IROC queries were also transmitted to sites through Emmes. These factors contributed to data submission delays that prevented real-time review of the radiation records and prolonged the data cleaning and query processes. Although the protocol stipulated that radiotherapy records be submitted to IROC within 60 days after treatment completion, this was not done consistently by either site. Most records were submitted in bulk at the completion of accrual over a year later in part related to the lack of protected time for compilation of radiotherapy records for submission. During IROC's review of radiotherapy records, sites were queried for clarifications and IROC worked directly with the site personnel to satisfactorily address the queries, which required significant effort from the individual sites. As a result, site contributions to the radiotherapy evaluation process continued beyond the final submission of the participant records. One site had been using 3D conformal radiotherapy routinely before this protocol was begun; however, conformal radiotherapy was not routinely used at the other site.

Discussion

Our results demonstrate that conducting multicenter radiotherapy studies at carefully selected sites in sub-Saharan Africa is feasible, with acceptable external beam radiotherapy

and brachytherapy delivery and complete data collection from participating centers allowing comprehensive quality assurance. It is important to note, however, that both centers that participated in AMC-081 were high-volume centers in sub-Saharan Africa with long track records for delivering radiotherapy, and results may not be generalizable to all institutions in the region. Indeed, inclusion as one of the first international AMC sites in sub-Saharan Africa was based on a competitive and rigorous formal application process that assessed institutional research capabilities across a range of HIV-associated malignancies, some of which do not require radiation therapy for optimal treatment. While the ability to deliver radiation therapy was a positive factor in choosing potential AMC sites, it was only one of many factors considered. Thus, while we do not presume that the results of this study are representative of those that would be obtained across a region that includes more than 20 countries and more than 1 billion people, this small study helps identify implementation issues that would facilitate the development of larger, more inclusive trials with more participants and more sites.

Although feasibility was demonstrated, some challenges were identified despite the highly selective nature of the sites chosen to participate. AMC-081 was the first AMC-sponsored therapeutic study opened at these sites and was the first time the AMC worked with IROC for a radiotherapy study. Thus, processes had to be developed to collect and coordinate the submission of data to IROC and distribution of IROC queries to the sites. The lack of electronic methods at the time to submit the data records and conduct the query process as outlined above complicated the study, and as a result no participant data was received within 60 days—the stated study goal. If future data submissions can be performed electronically, then data upload and querying will be much less challenging. IROC review could occur then on a rolling basis, potentially allowing real-time feedback and mid-course corrections. Of note, the participating sites submitted all the required files and IROC was able to evaluate all cases at the conclusion of the study; however, real-time feedback regarding the appropriateness of brachytherapy implants or external beam radiotherapy fields could not be provided. For example, doses to points A and B, ICRU bladder, or ICRU rectum required correction in >50% of the implants. For many of the patients, the incorrect points were defined over multiple implants likely due to lack of training, particularly regarding identification of point B. If these dose discrepancies had been identified earlier, a correction plan could have been formalized and subsequent corrections would likely have been limited. Also, as IMRT is being considered for future studies through the AMC, methods for real-time review of contours and plans will need to be instituted to ensure appropriate contouring and treatment planning. Allocating appropriate resources on site to support data submission and response to queries should also be identified before study initiation, particularly if real-time radiotherapy review is required.

Another potential limitation of our analysis is that AMC-081 was conducted between 2014–2016 and both external beam radiotherapy and brachytherapy techniques have evolved since the study completed, particularly the increased incorporation of 3D image guided brachytherapy with either CT or MR imaging and intensity modulated external beam radiotherapy(14,15). However, both centers that participated continue to employ radiotherapy techniques that were utilized in AMC-081 and thus the results are still relevant to the region.

As the capability for radiotherapy grows in LMICs, cooperative group studies that include radiotherapy will increase the need for robust methods to ensure quality assurance and appropriate documentation of treatment delivered as required by the clinical trials. These clinical trials may also include advanced radiotherapy techniques such as IMRT and stereotactic body radiotherapy or image-guided brachytherapy, as these techniques are increasingly used in LMICs. Methods to ensure implementation and delivery of these resource-intense radiotherapy techniques are necessary to ensure high-quality reporting of a clinical trial as well as optimal clinical care of the participant. As demonstrated by the results of several prospective clinical trials, high-quality radiotherapy is critical to the success of combined-modality therapy. For example, errors related to inappropriate brachytherapy geometry (unacceptable symmetry of ovoids to tandem, displacement of ovoids relative to cervical os, or inappropriate vaginal packing) resulted in a significantly increased risk of locoregional recurrence or lower disease-free survival rates in women with cervical cancer who participated in two prospective cooperative group trials.(16) Moreover, in TROG (Tran Tasman Radiation Oncology Group) 02.02, a study of chemoradiotherapy with or without tirapazamine for locally advanced oropharyngeal cancer, lack of protocol compliance was associated with significantly inferior overall survival and increased locoregional failure.(17) Furthermore, an earlier study by IROC Houston examining deficiencies observed in radiotherapy facilities during on-site evaluations identified an average of 3.1 deficiencies (dosimetric, mechanical, or programmatic) at each institution visited.(18)

Conclusions

The results of this study are important as they represent the first NCI-supported cooperative group clinical trial completed in sub-Saharan Africa that included radiotherapy and demonstrate the feasibility of such studies in carefully selected sites in limited resource settings. As the technology capabilities for radiotherapy grow in additional LMICs, the number of clinical trials being conducted should correspondingly increase. Incorporation of IMRT, stereotactic body radiotherapy, image-guided radiotherapy and even standard radiotherapy techniques into clinical trials will require robust quality assurance review of radiotherapy plans and delivery methods to ensure high quality reporting of clinical trial results, as is routinely done in clinical trials through US-based cooperative groups such as NRG, ECOG (Eastern Cooperative Oncology Group), and SWOG (Southwest Oncology Group).

Finally, by 2030 an estimated 75% of deaths from cancer will occur in LMICs; however, clinical trials and in particular randomized studies and studies including radiotherapy are disproportionately conducted in high-income countries, as highlighted in recent analyses.(9,19) The infrastructure required to conduct clinical trials can be significant, but AMC-081 demonstrates that conducting clinical trials with a radiotherapy component in sub-Saharan Africa is possible and supports continued efforts to improve access to clinical trials in LMICs to reduce disparities. As others have recently highlighted,(8) conducting prospective clinical trials in the regions with the greatest disease burden is critical both to ensure global health equity as well as demonstrate the generalizability of research findings.

Acknowledgements:

The authors would like to acknowledge Christine Wogan for her editorial assistance.

Conflict of interest:

Dr Lin receives grant support from the NCI. The University of Texas, MD Anderson Cancer Center has received grant funding from investigator initiated clinical trials for which Dr Lin has been the overall PI within the past 36 months including from Astrazeneca and Pfizer. Dr Palefsky reports institutional grant support from Merck and Bausch Health as well as honoraria for lectures, presentations, speakers bureaus from Merck and Theratechnologies. Dr Krown was the AMC Vice-Chair for International Activities during the development and conduct of AMC-081 and receivde direct payments for salary support from the AIDS Malignancy Consortium grant, through the Emmes Corp and the University of California Los Angeles. Dr. Einstein has advised or participated in educational speaking activities but does not receive an honorarium from any companies. In specific cases, his employer has received payment for his time spent for these activities from Merck, Douglas Pharmaceuticals Ltd, and PDS Biotechnologies. If travel required for meetings with industry, the company pays for Dr. Einstein's travel expenses. Rutgers has received grant funding for research-related costs of clinical trials that he has been the overall or local PI within the past 12 months from Inovio, Merck Sharp and Dohme Corp., Iovance, Papivax and VBL Therapeutics.

Funding:

Grant support (U01AI027660/AI/NIAID and UM1CA121947). Additionally, the Imaging and Radiation Oncology Core is funded by the National Cancer Institute (NCI) as a member of the National Clinical Trials Network.

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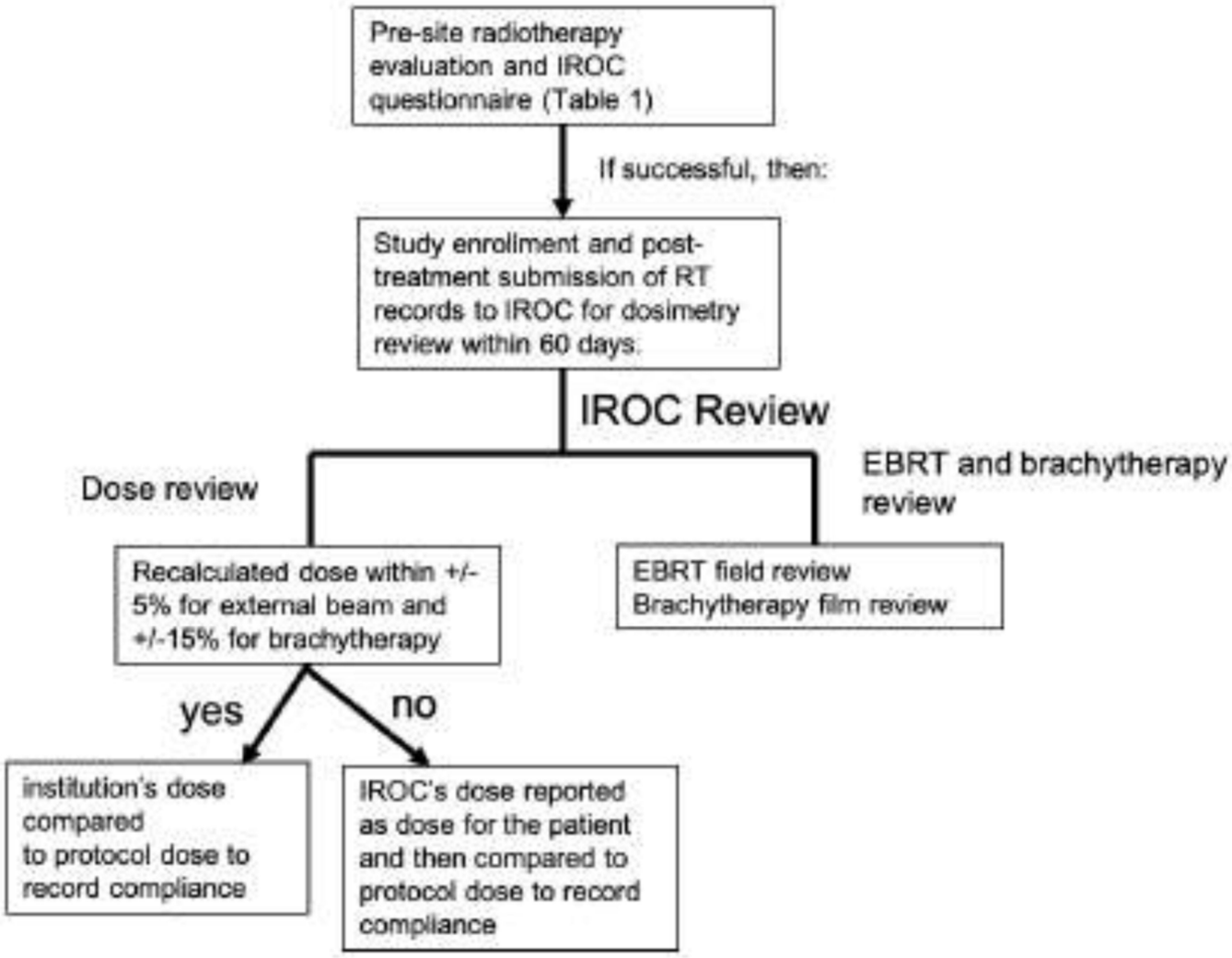

Fig. 1.

Flow chart of Imaging and Radiation Oncology Core (IROC) processes, from site credentialling to post-study review. EBRT, external beam radiotherapy.

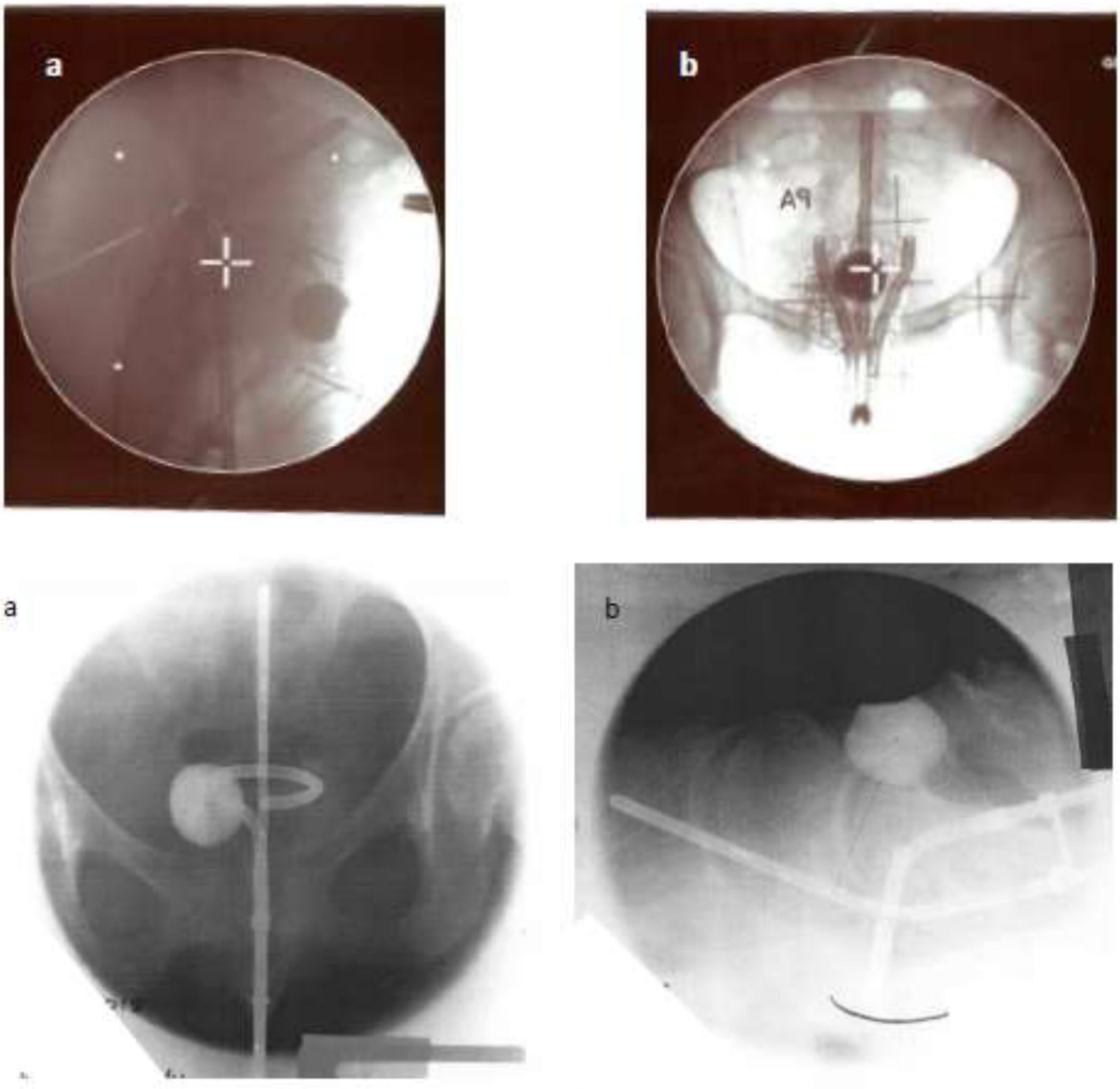

Fig. 2.

A, Orthogonal X ray images from site 1: a, lateral; b, posteroanterior. B, Orthogonal X ray images from site 2: a, posteroanterior; b, lateral.

Table 1.

Data required for radiotherapy site credentialing for AMC-081

• Machine output calibration for each megavoltage photon beam
• Brachytherapy source assay and manufacturer's source certificate
• Standards lab calibration certificate for ionization and well chambers and electrometers for both external beam RT and brachytherapy
• Documentation of successful participation in IROC Houston's mailed dosimetry program *

* provides an independent check of the machine output

Abbreviations: AMC, AIDS Malignancy Consortium; IROC, Imaging and Radiation Oncology Core

Table 2.

Radiotherapy data submission requirements for AMC-081

External beam documentation	Brachytherapy documentation
CT simulation images	Orthogonal AP and lateral films for each brachytherapy insertion
Radiotherapy external beam plan: • Beam's eye view • Dose-volume histograms • Isodose distribution through the center of the volume	Brachytherapy summary of doses for each insertion: • Point A • Point B • ICRU rectal dose point • ICRU bladder dose point
On-line external beam dosimetry form	Source activities for each brachytherapy insertion
Daily external beam dose treatment records	Dwell times and positions for each brachytherapy insertion
Weekly portal films	
Completed online external beam summary form	

Abbreviations: AMC, AIDS Malignancy Consortium; AP, anteroposterior; ICRU, International Commission on Radiation Units and Measurements.

Table 3.

Adherence to radiotherapy protocol specifications for AMC-081

Specification	Frequency (Percent)
Tumor dose	
Per protocol	35 (92.1)
Minor high	2 (5.3)
Major low	1 (2.6)
Total treatment time	
Per protocol	30 (81.1)
Minor too long	6 (16.2)
Major too long	1 (2.7)
External beam shielding normal tissues	
Per protocol	38 (100)
External beam field placement	
Per protocol	37 (97.4)
Minor deviation	1 (2.6)
External beam field deviation	
Too high	1 (2.6)
Too narrow	1 (2.6)
Missing	36 (94.7)
Intracavitary placement*	
Per protocol	38 (100)
Treatment modification	
Yes	11 (28.9)
No	27 (71.0)
Unplanned delay	
Yes	11 (28.9)
No	27 (71.0)
Final treatment review	
Per protocol	22 (57.9)
Minor deviation	15 (39.5)
Major deviation	1 (2.6)

* verified by review of orthogonal film

Abbreviation: AMC, AIDS Malignancy Consortium