

# ACR–ABS–ASTRO PRACTICE PARAMETER FOR TRANSPERINEAL PERMANENT BRACHYTHERAPY OF PROSTATE CANCER

The American College of Radiology, with more than 40,000 members, is the principal organization of radiologists, radiation oncologists, and clinical medical physicists in the United States. The College is a nonprofit professional society whose primary purposes are to advance the science of radiology, improve radiologic services to the patient, study the socioeconomic aspects of the practice of radiology, and encourage continuing education for radiologists, radiation oncologists, medical physicists, and persons practicing in allied professional fields.

The American College of Radiology will periodically define new practice parameters and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice parameter and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review and approval. The practice parameters and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice parameter and technical standard by those entities not providing these services is not authorized.

## PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care<sup>1</sup>. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner considering all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by variables such as the condition of the patient, limitations of available resources, or advances in knowledge or technology after publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document may consider documenting in the patient record information sufficient to explain the approach taken.

The practice of medicine involves the science, and the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to the guidance in this document will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The purpose of this document is to assist practitioners in achieving this objective.

---

<sup>1</sup> *Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing*, 831 N.W.2d 826 (Iowa 2013) Iowa Supreme Court refuses to find that the "ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures (Revised 2008)" sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, *Stanley v. McCarver*, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.

## I. INTRODUCTION

This practice parameter was revised collaboratively by the American College of Radiology (ACR), and the American Brachytherapy Society (ABS), and the American Society for Radiation Oncology (ASTRO).

Radical prostatectomy, external-beam radiotherapy, and prostate brachytherapy all represent well-established options for the treatment of prostate cancer [1-4]. Active surveillance can and should be considered in appropriately selected patients with low-risk disease [5].

Patients with clinically localized prostate cancer can be treated with radical prostatectomy, external-beam radiotherapy, or prostate brachytherapy. It is required that the patient have an understanding of the risks and benefits of each option in order to make an informed decision. It is recommended that patients with localized prostate cancer consult with both a radiation oncologist and urologist in order to achieve this aim.

A literature search was performed and reviewed to identify published articles regarding practice parameters and technical standards in brachytherapy of prostate cancer. Review of the recent scientific literature regarding permanent transperineal prostate seed implantation reveals significant variation in patient selection, brachytherapy techniques, and medical physics and dosimetric conventions. Despite this range of different procedural practices, interstitial low-dose-rate (LDR) brachytherapy has consistently been shown to be an effective component in the treatment of all prostate cancer risk strata either as monotherapy or as part of a multimodality regimen [3,6-10].

## II. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

### A. Radiation Oncologist

1. Certification in radiology by the American Board of Radiology (ABR) to a physician who focuses their professional practice to radiation oncology, or certification in Radiation Oncology or Therapeutic Radiology by the ABR, the American Osteopathic Board of Radiology, the Royal College of Physicians and Surgeons of Canada (RCPSC), or the Collège des Médecins du Québec may be considered proof of adequate qualification.  
or
2. Satisfactory completion of a residency program in radiation oncology approved by the Accreditation Council for Graduate Medical Education (ACGME), (RCPSC), the Collège des Médecins du Québec, or the American Osteopathic Association (AOA).
3. The radiation oncologist should have formal training in prostate brachytherapy. If this training was not obtained during an ACGME-approved residency or fellowship program, the radiation oncologist should comply with the following requirements:
  - a. Appropriate training from an experienced brachytherapist in transrectal ultrasound (TRUS), computed tomography (CT), or magnetic resonance imaging (MRI)-guided prostate brachytherapy.
  - b. Additional training through participation in hands-on workshops or under the supervision of a qualified proctoring physician. The proctoring physician should be an experienced prostate brachytherapist with the proficiency to perform the mechanics of the implant procedure and critically assess the dosimetric quality of the implant. The radiation oncologist should have delineated hospital privileges for performing this procedure. These workshops must provide the radiation oncologist with personal supervised experience with seed placement and implant evaluation.

### B. Qualified Medical Physicist

For the qualifications of the Qualified Medical Physicist, see the [ACR–AAPM Technical Standard for the Performance of High-Dose-Rate Brachytherapy Physics](#) or the [ACR–AAPM Technical Standard for the Performance of Low-Dose-Rate Brachytherapy Physics](#) [11,12].

### C. Radiation Therapist

The radiation therapist must fulfill state licensing requirements and be certified in radiation therapy by the American Registry of Radiologic Technologists (ARRT).

### D. Dosimetrist

Certification by the Medical Dosimetrist Certification Board is recommended.

### E. Patient Support Staff

Individuals involved in the nursing care of patients should have education or experience in the care of radiation therapy patients.

## III. PATIENT SELECTION CRITERIA

Candidates for treatment with prostate seed implant alone, as monotherapy, include those for whom there is a significant likelihood that their prostate cancer could be encompassed by the dose distribution from permanent prostate seed implant alone. Patients with a significant risk of disease outside of the implant volume may benefit from the addition of external-beam irradiation and/or androgen deprivation therapy (ADT). Specific treatment schemas are evolving, as there are conflicting data regarding the efficacy of combined therapies relative to monotherapy. Consequently, it is suggested that each facility establish and follow its own practice parameters. Ongoing clinical trials will help to better define indications.

A number of different risk stratification systems exist. The majority of these systems divide prostate cancer patients into low-risk, intermediate-risk, and high-risk groups according to pretreatment prostate-specific antigen (PSA) level, Gleason score, and clinical stage [13,14]. The volume of cancer on the prostate biopsy specimen also has been shown to affect biochemical outcome and may prove to be useful in further subdividing the established risk categories [15,16]. The National Comprehensive Cancer Network (NCCN) risk criteria are the most commonly cited and represent the standard for most modern clinical trials [17]. Given the heterogeneity that exists within each of the risk groups, some risk classification systems are now substratifying the classic risk groups to very low, low, favorable intermediate, unfavorable intermediate, high, and very high risk. Monotherapy is sufficient treatment for low-risk prostate cancer patients. Assuming good implant quality, there are emerging data showing that intermediate-risk patients with favorable characteristics may also be adequately treated with monotherapy [18-25]. Focal (partial gland) brachytherapy is also being evaluated in the low- and favorable intermediate-risk prostate cancer population but at the present time is considered experimental and should only be performed in the setting of a clinical trial [22]. At the present time, most high-risk brachytherapy protocols include supplemental external beam with or without androgen suppression [18,26]. Retrospective studies have reported favorable outcomes comparing brachytherapy with radical prostatectomy and external-beam radiation therapy alone in the high-risk population [6,7,9,10,27]. Randomized controlled data demonstrate superior biochemical control when dose escalation is achieved with brachytherapy boost compared with external-beam therapy alone [2], though the addition of a brachytherapy boost is associated with a higher incidence of acute and late genitourinary toxicity [28].

External-beam treatment volume and the role of androgen suppression are areas of controversy. Extrapolation from external-beam radiation therapy data suggests that there may be a potential role for androgen suppression in patients with factors that place them at high risk of metastasis [29-31]. However, the role and duration of androgen suppression therapy in intermediate-risk and high-risk patients treated with brachytherapy have not been established [32].

When supplemental external-beam radiation therapy is used, the optimal treatment volume has not been established. Some investigators advocate the treatment of a whole-pelvic field in higher-risk patients. Other investigators believe an involved field around the prostate and immediately adjacent structures is appropriate [33-35].

Androgen suppression should not be routinely given for low-risk patients. It can be given to certain patients with large glands for volume reduction in those utilizing a technique that requires prostate downsizing [36].

The following are potential exclusion criteria for permanent seed brachytherapy:

1. Life expectancy of less than 10 years in the setting of low-risk prostate cancer
2. Unacceptable operative risk
3. Poor anatomy which, in the opinion of the radiation oncologist, could lead to a suboptimal implant (eg, large or poorly healed transurethral resection of the prostate (TURP) defect, large median lobe, large gland size, pubic arch interference, and inability to achieve the dorsal lithotomy position)
4. Significant obstructive uropathy
5. Lymph node involvement
6. Distant Metastasis

Modern prostate brachytherapy series demonstrate excellent biochemical and functional outcomes in patients younger than 50 years [37-39]. Young age should not be considered a contraindication to prostate brachytherapy.

There are limited contemporary studies reporting outcomes in patients with lymph node involvement treated with prostate brachytherapy as a component of their treatment [40-42]. The recent STAMPEDE H trial supports the use of two fractionation regimens of external radiation to the prostate in patients with low volume metastatic disease but does not address the role of dose intensification with brachytherapy [43]. Thus, brachytherapy is not favored as an appropriate option in such patients until more data are forthcoming, or it is further investigated with the scope of a clinical trial.

#### IV. SPECIFICATIONS OF THE PROCEDURE

##### A. Written Directive

The terms "written directive", "planning directive", and "prescription" are often used interchangeably. To avoid confusion in this document, "written directive" will be used to indicate the statement of intent required by the Code of Federal Regulations. This is distinct from dosimetric goals, which are used to evaluate the quality of the implant in terms of achieved dose distribution. The word "prescription" is not used.

1. Prior to the start of implantation: State the treatment site, treatment intent (curative/palliative), radionuclide, and total source strength. In order to allow for sources planted outside the gland but placed intentionally to contribute to the dose make the treatment site "prostate and periprostatic tissues."
2. After the implantation but before the patient leaves the posttreatment recovery area: State treatment site, the number of sources implanted, the total source strength implanted, and the date

##### B. Implant Treatment Planning

Dosimetric planning should be performed in all patients prior to or during seed implantation. TRUS, CT scanning, or MRI should be used to aid in the treatment planning process [44-51].

##### C. Intraoperative Procedure

A transperineal approach under TRUS guidance is recommended for seed implantation. Ideally, the full definition of the prostate in both longitudinal and transverse planes should be available. Typically, a probe with a frequency range between 5.0 and 12.0 MHz is used for the TRUS. It is recommended to use a high-resolution biplanar ultrasound probe with axial and sagittal capability and dedicated prostate brachytherapy software, which displays perineal template and coordinates.

- There are several acceptable methods for seed insertion. These include, but are not limited to, the following:
  1. Using a preloaded needle technique
    - a. The preloaded technique is performed based on a preplan and can be used in

- conjunction with intraoperative planning.
  - b. Needles can be placed one at a time, all at once, by row, or based on peripheral and central locations.
  - c. Seeds can be "stranded," "linked," or "loose" within each needle [52].
2. Using a free-seed technique
- a. A Mick applicator or similar device is used to load the seeds into the prostate.
  - b. Free-seed loading can be based on a preplan or an intraoperative plan.
  - c. Needles can be placed one at a time, all at once, by row, or based on peripheral and central locations.

There are some studies showing that injection of an absorbable hydrogel spacer can be used to reduce rectal dose in patients undergoing LDR brachytherapy [53]. The hydrogel can be placed in the space between the posterior prostate and anterior rectum under ultrasound guidance. The timing of hydrogel placement is left at the discretion of the brachytherapist and can depend on a number of factors including the method of dosimetric planning, and whether the implant is done in conjunction with supplemental external beam radiation therapy. Further studies are needed to determine whether hydrogel placement reduces rectal toxicity in the setting of permanent prostate brachytherapy.

For dose calculations, the AAPM Task Group No. 43 Report (TG-43) [54-56] and its successors should be adopted. The precise radiation dose necessary for eradicating prostate cancer by brachytherapy is not absolutely defined. Based on available data, the following recommendations are made for dose prescriptions: for patients with low-risk or favorable disease treated by monotherapy, the prescription dose ranges from 110 to 125 Gy for palladium-103 and 140 to 160 Gy for iodine-125 [57-59]. In recent years, there has been experience with cesium-131, and if that isotope is used, reference to current literature is advised. The currently recommended dose is 115 Gy if cesium-131 is used as monotherapy. Doses of approximately 85 Gy are being investigated when combined with external-beam radiation therapy [60]. With external beam plus brachytherapy the recommended external-beam dose to the prostate and periprostatic area is in the range of 20 to 50.4 Gy [19]. Implant technique has been shown to vary substantially among different institutions in terms of seed strength, dose homogeneity, and extracapsular seed placement/margins [61]. With this being the case, dosimetric parameters such as D90 (the minimum dose received by 90% of the target volume) and V100 (the percentage of the target volume receiving 100% of the prescription dose) should be reported in conjunction with prescribed dose to provide a meaningful assessment of implant quality.

Whole-pelvic irradiation may be used in those cases at high risk for pelvic node metastases. The palladium-103 prescription boost dose is in the range of 80 to 110 Gy, and for iodine-125 the prescription boost dose is 100 to 110 Gy [33,38,46,47,62]. When brachytherapy is used in conjunction with external-beam radiation, it is recommended that the treating clinician consider the biologically effective dose (BED) that results from the combination of these two modalities. Several formulas have been proposed to account for the different dose-fractionation schemas that exist for the external-beam component of treatment and also the various isotopes that can be used in the brachytherapy implant [59,63,64]. Given the known correlation between BED and treatment outcome, every effort should be made to attain a BED threshold that will maximize cure while minimizing treatment-related morbidity.

There are no recommendations regarding the selection of radionuclide. One randomized trial examined differences between the two isotopes (palladium-103 and iodine-125), which noted no significant differences in long-term morbidity or PSA-based

cancer control [65]. Experience with cesium-131 is less established compared with the other two isotopes, but 5-year biochemical control rates are favorable, and a recently published phase II study demonstrated similar quality of life outcomes among patients treated with palladium-103, iodine-125, and cesium-131 [66,67].

#### D. Postimplant Procedures

Cystoscopy may be performed after the procedure. Cystoscopy allows for removal of blood clots and misplaced seeds in the bladder and/or urethra. Patients should be advised that there is a risk of seed migration to the lungs or other organs, particularly if loose seeds are employed. Patients should be instructed to monitor their urine for the first three days following the implant procedure. If a seed is passed, it should be placed in a provided container and returned to the radiation department for proper storage/disposal. Urinary anesthetics, antispasmodics, analgesics, perineal ice packs, and stool softeners may be added in symptomatic patients. Consideration should be given to the prophylactic use of alpha blockers before and after the procedure [68].

### V. DOCUMENTATION

Reporting and communication should be in accordance with the [ACR–ARS Practice Parameter for Communication: Radiation Oncology](#) [69].

### VI. POSTIMPLANT DOSIMETRY

Postimplant dosimetry assessment is mandatory for each patient. The intent is not merely documentation of seeds and evaluation for a medical event; CT- and/or MRI-based postimplant dosimetry assessment evaluates the quality of the implant. Postimplant dosimetry expresses the actual dose delivered and identifies variance from the original treatment plan. Because quality is correlated with outcome and morbidity, postimplant dosimetry is an objective tool for self-assessment and improvement. Plain radiographs alone are not adequate for dosimetric analysis. We recommend the use of image-based planning such as CT and/or MRI to be completed within approximately 60 days of the brachytherapy procedure to evaluate the relationship of the seeds and the prostate, bladder, and rectum [70-75].

The optimal timing for obtaining the postimplant CT and/or MRI is not known. Implant dosimetry will vary in a predictable fashion depending on when the imaging evaluation is performed. Imaging obtained within 24 hours of the implant procedure will result in lower calculated doses to the prostate and anterior rectal wall, whereas day 30 imaging will predict higher doses to these respective structures [73,76-78]. Some studies suggest an interval of 2 to 6 weeks postimplant (AAPM TG-64 and TG-137 Reports) [79,80]. Others have argued that dosimetric evaluation should be performed within 24 hours of implant because this allows for immediate correction of dose deficiency and allows for implant assessment at the time of maximal prostatic edema [81,82]. Regardless of convention, it is preferred that the timing of postimplant image acquisition be kept consistent within each practice. The TRUS volume study can be fused with the postimplant CT or MRI for the purposes of postimplant dosimetry [83].

Significant intraobserver variability in the contouring of prostate volumes and normal structures can be noted on postimplant CT scans, and this should be considered before drawing specific inferences regarding dosimetric parameters [84,85].

The following parameters should be reported:

1. The prescribed (intended) dose.
2. The D90, defined as the minimum dose received by 90% of the target volume as delineated on the postimplant CT, and the V100, defined as the percentage of the target volume delineated on the postimplant CT receiving 100% of the prescribed dose [86-90]. A D90 of at least 90% of the prescription dose and a V100 that corresponds to at least 90% of the contoured prostate are recommended as the

current standard of care, but this should be balanced with respect to the morbidity of the adjacent normal tissue doses [58,59,91-95]. Reporting of the V150 and V200 (ie, the percentage of prostate volume receiving 150% and 200% of prescribed dose, respectively) should also be considered [88].

3. Doses to organs at risk (OAR), including rectum and prostatic urethra [96-98]. The dose to the rectum is commonly reported as the RV100 and RV150, the volumes in cubic centimeters of the rectal wall receiving 100% and 150% of the prescribed dose, respectively. A peripheral loading pattern is recommended to avoid extreme central doses to the urethra. The performance of postprocedure urethral dosimetry is favored if imaging and postimplant timing readily permit it. Dose to the penile bulb may be reported, but there are conflicting results regarding the clinical utility of this practice parameter [99,100].

## VII. RADIATION SAFETY AND PHYSICS QUALITY CONTROL

### A. TRUS Imaging System

The report of the AAPM Ultrasound Task Group 128 [101] for acceptance testing and quality assurance and the [ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment](#) [102] provide guidance for ultrasound imaging units. Physicists and physicians should pay attention to spatial resolution, grayscale contrast, geometric accuracy, and distance measurement. The correspondence between the electronic grid pattern on the ultrasound image and the template grid pattern should be verified prior to the procedure as part of the ultrasound quality assurance.

### B. Computerized Planning System

The computerized planning system should be commissioned by the Qualified Medical Physicist prior to clinical use. The AAPM TG-40 Report [103] should be followed. In addition, dose-rate calculations from planning systems should be compared to the AAPM TG-43 Report [56,104]. The Qualified Medical Physicist and/or radiation oncologist should also be familiar with the AAPM TG-64 Report [80].

### C. Brachytherapy Source Calibrations

The recommendations set forth by the AAPM TG-40 [103], TG-56 [105], and TG-64 [80] reports and the recommendations of AAPM Low Energy Brachytherapy Source Calibration Working Group [106] should be followed for calibrating brachytherapy sources.

### D. Implantation Procedure

The radiation oncologist will verify the position of the prostate gland relative to the template coordinates. The total number of seeds implanted should be verified at the end of the implant procedure. At the completion of the implant, a radiation survey of the patient and the room should be conducted with an appropriately calibrated survey instrument. Patient survey measurements should be performed at the surface of the patient and at 1m distant from the patient. The room survey should include the vicinity of the implanted area, the floor, the waste fluids/materials, linens, and all applicators. Prior to the release of the patient, the Qualified Medical Physicist, or an appropriately trained member of the physics staff, and/or the radiation oncologist or radiation safety staff should review the postimplantation survey results to confirm that all pertinent federal and state regulations regarding the release of patients with radioactive sources have been followed. The brachytherapy team must follow the new 10 CFR Part 35 applicable to the permanent implant brachytherapy.

### E. Postimplant Radiation Safety Considerations

Patients should be provided with written descriptions of the radiation protection guidelines, including, but not limited to, discussion of potential limitations of patient contact with minors and pregnant women. This is the responsibility of the licensee. The radiation oncologist or their designee (radiation safety officer or medical physicist) should provide the verbal and written radiation safety instructions post implant. This

description must be in compliance with state and federal regulations.

## VIII. FOLLOW-UP

Follow-up of definitively treated cancer patients is part of radiation oncology practice, as noted in the [ACR–ARS Practice Parameter for Radiation Oncology \[107\]](#). Postoperative follow-up should consist of sufficient visits within the first 3 months to ensure patient safety and comfort and to minimize acute complications associated with the radiation therapy procedure. The frequency and sequence of subsequent visits may vary among the radiation oncologist, urologist, and other physicians involved in the care of the patient. The radiation oncologist should make an effort to obtain long-term follow-up on patient status.

The best definition of biochemical PSA failure has yet to be determined for brachytherapy patients [108]. The current ASTRO Phoenix PSA failure definition is most commonly used [109]. PSA failure can also be defined according to an absolute threshold (ie, PSA exceeding a certain level), but when using such a definition, adequate time should be allowed for the PSA to reach its nadir. One benefit to a threshold definition of biochemical failure is that it better facilitates comparison of treatment outcome with prostatectomy [110]. Consideration should be given to the PSA bounce or spike phenomenon in cases of spurious PSA elevation following implantation [111-113]. Although most spikes occur at 18 to 30 months, they can occur much later. Other clinical laboratory and radiologic studies may be performed when clinically indicated. If there is concern regarding recurrence, other treatment options can be considered.

## IX. SUMMARY

Transperineal prostate brachytherapy is an effective modality for treating prostate cancer. It's safe and effective execution is a complex process that requires coordination between the radiation oncologist and other health professionals. Appropriate patient selection criteria and quality assurance procedures are important for a successful program.

## ACKNOWLEDGEMENTS

This practice parameter was revised according to the process described under the heading *The Process for Developing ACR Practice Parameters and Technical Standards* on the ACR website (<https://www.acr.org/Clinical-Resources/Practice-Parameters-and-Technical-Standards>) by the Committee on Practice Parameters – Radiation Oncology of the ACR Commission on Radiation Oncology in collaboration with the ABS and ASTRO.

Collaborative Committee – members represent their societies in the initial and final revision of this practice parameter

### ACR

Nathan H.J. Bittner, MD, MS, Chair

Gregory S. Merrick, MD, FACR

Peter Orio, DO, MS

### ASTRO

Martin King, MD

Colleen A F Lawton MD, FACR, FASTRO

Zoubir Ouhib, MS, FACR, FABS, FAAPM

### ABS



Collaborative Committee – members represent their societies in the initial and final revision of this practice parameter

Brett Cox, MD

Brian Davis, MD, PhD, FABS

Peter Rossi, MD

Tim Showalter, MD, MPH

Committee on Practice Parameters – Radiation Oncology

(ACR Committee responsible for sponsoring the draft through the process)

Naomi R. Schechter, MD, Chair

Join Y. Luh, MD

Nathan H. J. Bittner, MD, MS

Helen A. Shih, MD

Samuel T. Chao, MD

Paul E. Wallner, DO, FACR

Neil B. Desai, MD

Kristina L. Woodhouse, MD

Beth A Erickson-Wittmann, MD

Ying Xiao, PhD

Matthew Harkenrider, MD

Sue S. Yom, MD, PhD

Mark Hurwitz, MD

William Small, Jr, MD, FACR, Chair of the Commission on Radiation Oncology

Comments Reconciliation Committee

Monica Wood, MD, Chair

Colleen A.F. Lawton MD, FACR, FASTRO

David C. Beyer, MD, FACR, Co-Chair

Gregory S. Merrick, M.D., FACR, FABS

## Comments Reconciliation Committee

William Bice, PhD

David Morris, MD

Nathan Bittner, MD

Peter F. Orio, DO

Brett Cox, MD

Zoubir Ouhib, MS, FACR, FABS, FAAPM

Brian Davis, MD

Peter Rossi, MD

Richard Duszak Jr., MD, FACR

Naomi R. Schechter, MD

Christina E. Henson, MD

Tim Sholwalter, MD

Martin King, MD

William Small, Jr., MD, FACR

Amy L. Kotsenas, MD, FACR

## **REFERENCES**

1. Bill-Axelsson A, Holmberg L, Ruutu M, et al. Radical prostatectomy versus watchful waiting in early prostate cancer. *The New England journal of medicine* 2011;364:1708-17.
2. Morris WJ, Tyldesley S, Rodda S, et al. Androgen Suppression Combined with Elective Nodal and Dose Escalated Radiation Therapy (the ASCENDE-RT Trial): An Analysis of Survival Endpoints for a Randomized Trial Comparing a Low-Dose-Rate Brachytherapy Boost to a Dose-Escalated External Beam Boost for High- and Intermediate-risk Prostate Cancer. *International journal of radiation oncology, biology, physics* 2017;98:275-85.
3. Spratt DE, Zumsteg ZS, Ghadjar P, et al. Comparison of high-dose (86.4 Gy) IMRT vs combined brachytherapy plus IMRT for intermediate-risk prostate cancer. *BJU international* 2014;114:360-7.
4. Sylvester JE, Grimm PD, Blasko JC, et al. 15-Year biochemical relapse free survival in clinical Stage T1-T3 prostate cancer following combined external beam radiotherapy and brachytherapy; Seattle experience. *International journal of radiation oncology, biology, physics* 2007;67:57-64.
5. Klotz L, Vesprini D, Sethukavalan P, et al. Long-term follow-up of a large active surveillance cohort of patients with prostate cancer. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology* 2015;33:272-7.
6. Bittner N, Merrick GS, Galbreath RW, Butler WM, Adamovich E. Treatment outcomes with permanent brachytherapy in high-risk prostate cancer patients stratified into prognostic categories. *Brachytherapy* 2015;14:766-72.
7. Kishan AU, Cook RR, Ciezki JP, et al. Radical Prostatectomy, External Beam Radiotherapy, or External Beam Radiotherapy With Brachytherapy Boost and Disease Progression and Mortality in Patients With Gleason Score 9-10 Prostate Cancer. *JAMA* 2018;319:896-905.
8. Stock RG, Cahlon O, Cesaretti JA, Kollmeier MA, Stone NN. Combined modality treatment in the management of high-risk prostate cancer. *International journal of radiation oncology, biology, physics* 2004;59:1352-9.
9. Taira AV, Merrick GS, Butler WM, et al. Time to failure after definitive therapy for prostate cancer: implications for importance of aggressive local treatment. *Journal of contemporary brachytherapy*

2013;5:215-21.

10. Zelefsky MJ, Yamada Y, Pei X, et al. Comparison of tumor control and toxicity outcomes of high-dose intensity-modulated radiotherapy and brachytherapy for patients with favorable risk prostate cancer. *Urology* 2011;77:986-90.
11. American College of Radiology. ACR–AAPM technical standard for the performance of high-dose-rate brachytherapy physics. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/HDR-BrachyTS.pdf?la=en>. Accessed June 26, 2019.
12. American College of Radiology. ACR–AAPM technical standard for the performance of low-dose-rate brachytherapy physics. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/LDR-BrachyTS.pdf?la=en>. Accessed June 26, 2019.
13. Beyer DC, Thomas T, Hilbe J, Swenson V. Relative influence of Gleason score and pretreatment PSA in predicting survival following brachytherapy for prostate cancer. *Brachytherapy* 2003;2:77-84.
14. D'Amico AV, Whittington R, Malkowicz SB, et al. Pretreatment nomogram for prostate-specific antigen recurrence after radical prostatectomy or external-beam radiation therapy for clinically localized prostate cancer. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology* 1999;17:168-72.
15. D'Amico AV, Schultz D, Silver B, et al. The clinical utility of the percent of positive prostate biopsies in predicting biochemical outcome following external-beam radiation therapy for patients with clinically localized prostate cancer. *International journal of radiation oncology, biology, physics* 2001;49:679-84.
16. Merrick GS, Butler WM, Galbreath RW, Lief JH, Adamovich E. Relationship between percent positive biopsies and biochemical outcome after permanent interstitial brachytherapy for clinically organ-confined carcinoma of the prostate gland. *International journal of radiation oncology, biology, physics* 2002;52:664-73.
17. National Comprehensive Cancer Network. Available at: [https://www.nccn.org/store/login/login.aspx?ReturnURL=http://www.nccn.org/professionals/physician\\_gls/pdf/prostate.pdf](https://www.nccn.org/store/login/login.aspx?ReturnURL=http://www.nccn.org/professionals/physician_gls/pdf/prostate.pdf). Accessed March 10, 2014.
18. Marshall RA, Buckstein M, Stone NN, Stock R. Treatment outcomes and morbidity following definitive brachytherapy with or without external beam radiation for the treatment of localized prostate cancer: 20-year experience at Mount Sinai Medical Center. *Urologic oncology* 2014;32:38 e1-7.
19. Merrick GS, Wallner KE, Butler WM, et al. 20 Gy versus 44 Gy of supplemental external beam radiotherapy with palladium-103 for patients with greater risk disease: results of a prospective randomized trial. *International journal of radiation oncology, biology, physics* 2012;82:e449-55.
20. Merrick GS, Wallner KE, Galbreath RW, et al. Is supplemental external beam radiation therapy necessary for patients with higher risk prostate cancer treated with 103Pd? Results of two prospective randomized trials. *Brachytherapy* 2015;14:677-85.
21. Prestidge BR, Winter K, Sanda MG, et al. Initial report of NRG Oncology/RTOG 0232: A phase 3 study comparing combined external beam radiation and transperineal interstitial permanent brachytherapy with brachytherapy alone for select patients with intermediate-risk prostatic carcinoma. *Int J Radiat Oncol Biol Phys.* 2016;96:S4.
22. SS M, IT S, SE S. Focal application of low-dose-rate brachytherapy for prostate cancer: A pilot study. *Journal of contemporary brachytherapy* 2017;9:197-208.
23. Stone NN, Potters L, Davis BJ, et al. Multicenter analysis of effect of high biologic effective dose on biochemical failure and survival outcomes in patients with Gleason score 7-10 prostate cancer treated with permanent prostate brachytherapy. *International journal of radiation oncology, biology, physics* 2009;73:341-6.
24. Cosset JM, Flam T, Thiounn N, et al. Selecting patients for exclusive permanent implant prostate brachytherapy: the experience of the Paris Institut Curie/Cochin Hospital/Necker Hospital group on 809 patients. *International journal of radiation oncology, biology, physics* 2008;71:1042-8.
25. Frank SJ, Grimm PD, Sylvester JE, et al. Interstitial implant alone or in combination with external beam radiation therapy for intermediate-risk prostate cancer: a survey of practice patterns in the United States. *Brachytherapy* 2007;6:2-8.
26. Liss AL, Abu-Isa EI, Jawad MS, et al. Combination therapy improves prostate cancer survival for patients with potentially lethal prostate cancer: The impact of Gleason pattern 5. *Brachytherapy* 2015;14:502-10.
27. Ciezki JP, Weller M, Reddy CA, et al. A Comparison Between Low-Dose-Rate Brachytherapy With or Without

- Androgen Deprivation, External Beam Radiation Therapy With or Without Androgen Deprivation, and Radical Prostatectomy With or Without Adjuvant or Salvage Radiation Therapy for High-Risk Prostate Cancer. *International journal of radiation oncology, biology, physics* 2017;97:962-75.
28. Rodda S, Tyldesley S, Morris WJ, et al. ASCENDE-RT: An Analysis of Treatment-Related Morbidity for a Randomized Trial Comparing a Low-Dose-Rate Brachytherapy Boost with a Dose-Escalated External Beam Boost for High- and Intermediate-Risk Prostate Cancer. *International journal of radiation oncology, biology, physics* 2017;98:286-95.
  29. Bolla M, Collette L, Blank L, et al. Long-term results with immediate androgen suppression and external irradiation in patients with locally advanced prostate cancer (an EORTC study): a phase III randomised trial. *Lancet* 2002;360:103-6.
  30. Bolla M, Descotes JL, Artignan X, Fournier P. Adjuvant treatment to radiation: combined hormone therapy and external radiotherapy for locally advanced prostate cancer. *BJU international* 2007;100 Suppl 2:44-7.
  31. Horwitz EM, Bae K, Hanks GE, et al. Ten-year follow-up of radiation therapy oncology group protocol 92-02: a phase III trial of the duration of elective androgen deprivation in locally advanced prostate cancer. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology* 2008;26:2497-504.
  32. Keyes M, Merrick G, Frank SJ, Grimm P, Zelefsky MJ. American Brachytherapy Society Task Group Report: Use of androgen deprivation therapy with prostate brachytherapy-A systematic literature review. *Brachytherapy* 2017;16:245-65.
  33. Bittner N, Merrick GS, Wallner KE, Butler WM, Galbreath R, Adamovich E. Whole-pelvis radiotherapy in combination with interstitial brachytherapy: does coverage of the pelvic lymph nodes improve treatment outcome in high-risk prostate cancer? *International journal of radiation oncology, biology, physics* 2010;76:1078-84.
  34. Lawton CA, DeSilvio M, Roach M, 3rd, et al. An update of the phase III trial comparing whole pelvic to prostate only radiotherapy and neoadjuvant to adjuvant total androgen suppression: updated analysis of RTOG 94-13, with emphasis on unexpected hormone/radiation interactions. *International journal of radiation oncology, biology, physics* 2007;69:646-55.
  35. Roach M, 3rd, DeSilvio M, Lawton C, et al. Phase III trial comparing whole-pelvic versus prostate-only radiotherapy and neoadjuvant versus adjuvant combined androgen suppression: Radiation Therapy Oncology Group 9413. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology* 2003;21:1904-11.
  36. Merrick GS, Butler WM, Wallner KE, et al. Androgen deprivation therapy does not impact cause-specific or overall survival in high-risk prostate cancer managed with brachytherapy and supplemental external beam. *International journal of radiation oncology, biology, physics* 2007;68:34-40.
  37. Langley SEM, Soares R, Uribe J, et al. Long-term oncological outcomes and toxicity in 597 men aged 2018;121:38-45.
  38. Merrick GS, Wallner KE, Galbreath RW, et al. Biochemical and functional outcomes following brachytherapy with or without supplemental therapies in men  $\leq$  50 years of age with clinically organ-confined prostate cancer. *American journal of clinical oncology* 2008;31:539-44.
  39. Winoker JS, Omidale OO, Stock RG, Stone NN. Long-term oncological and functional outcomes support use of low-dose-rate brachytherapy with or without external beam radiation in young men ( 2019;18:192-97.
  40. Leibel SA, Fuks Z, Zelefsky MJ, Whitmore WF, Jr. The effects of local and regional treatment on the metastatic outcome in prostatic carcinoma with pelvic lymph node involvement. *International journal of radiation oncology, biology, physics* 1994;28:7-16.
  41. Okamoto K, Wada A, Kohno N. High biologically effective dose radiation therapy using brachytherapy in combination with external beam radiotherapy for high-risk prostate cancer. *Journal of contemporary brachytherapy* 2017;9:1-6.
  42. Rusthoven CG, Carlson JA, Waxweiler TV, et al. The impact of definitive local therapy for lymph node-positive prostate cancer: a population-based study. *International journal of radiation oncology, biology, physics* 2014;88:1064-73.
  43. Parker CC, James ND, Brawley CD, et al. Radiotherapy to the primary tumour for newly diagnosed, metastatic prostate cancer (STAMPEDE): a randomised controlled phase 3 trial. *Lancet* 2018;392:2353-66.
  44. Hastak SM, Gammelgaard J, Holm HH. Transrectal ultrasonic volume determination of the prostate--a preoperative and postoperative study. *The Journal of urology* 1982;127:1115-8.
  45. Holm HH, Juul N, Pedersen JF, Hansen H, Stroyer I. Transperineal 125iodine seed implantation in prostatic

- cancer guided by transrectal ultrasonography. *The Journal of urology* 1983;130:283-6.
46. Narayana V, Roberson PL, Pu AT, Sandler H, Winfield RH, McLaughlin PW. Impact of differences in ultrasound and computed tomography volumes on treatment planning of permanent prostate implants. *International journal of radiation oncology, biology, physics* 1997;37:1181-5.
  47. Narayana V, Roberson PL, Winfield RJ, McLaughlin PW. Impact of ultrasound and computed tomography prostate volume registration on evaluation of permanent prostate implants. *International journal of radiation oncology, biology, physics* 1997;39:341-6.
  48. Nath R, Meigooni AS, Melillo A. Some treatment planning considerations for 103Pd and 125I permanent interstitial implants. *International journal of radiation oncology, biology, physics* 1992;22:1131-8.
  49. Roy JN, Wallner KE, Chiu-Tsao ST, Anderson LL, Ling CC. CT-based optimized planning for transperineal prostate implant with customized template. *International journal of radiation oncology, biology, physics* 1991;21:483-9.
  50. Stock RG, Stone NN, Wesson MF, DeWyngaert JK. A modified technique allowing interactive ultrasound-guided three-dimensional transperineal prostate implantation. *International journal of radiation oncology, biology, physics* 1995;32:219-25.
  51. Venkatesan AM, Stafford RJ, Duran C, Soni PD, Berlin A, McLaughlin PW. Prostate magnetic resonance imaging for brachytherapists: Anatomy and technique. *Brachytherapy* 2017;16:679-87.
  52. Merrell KW, Davis BJ, Goulet CC, et al. Reducing seed migration to near zero with stranded-seed implants: Comparison of seed migration rates to the chest in 1000 permanent prostate brachytherapy patients undergoing implants with loose or stranded seeds. *Brachytherapy* 2019;18:306-12.
  53. Taggar AS, Charas T, Cohen GN, et al. Placement of an absorbable rectal hydrogel spacer in patients undergoing low-dose-rate brachytherapy with palladium-103. *Brachytherapy* 2018;17:251-58.
  54. Beaulieu L, Carlsson Tedgren A, Carrier JF, et al. Report of the Task Group 186 on model-based dose calculation methods in brachytherapy beyond the TG-43 formalism: current status and recommendations for clinical implementation. *Medical physics* 2012;39:6208-36.
  55. Rivard MJ, Ballester F, Butler WM, et al. Erratum: "Supplement 2 for the 2004 update of the AAPM Task Group No. 43 Report: Joint recommendations by the AAPM and GEC-ESTRO" [*Med. Phys.* Vol 44 (9), e297-e338 (2017)]. *Medical physics* 2018;45:971-74.
  56. Rivard MJ, Butler WM, DeWerd LA, et al. Supplement to the 2004 update of the AAPM Task Group No. 43 Report. *Medical physics* 2007;34:2187-205.
  57. Beyer D, Nath R, Butler W, et al. American brachytherapy society recommendations for clinical implementation of NIST-1999 standards for (103)palladium brachytherapy. The clinical research committee of the American Brachytherapy Society. *International journal of radiation oncology, biology, physics* 2000;47:273-5.
  58. Stock RG, Stone NN, Tabert A, Iannuzzi C, DeWyngaert JK. A dose-response study for I-125 prostate implants. *International journal of radiation oncology, biology, physics* 1998;41:101-8.
  59. Stone NN, Potters L, Davis BJ, et al. Customized dose prescription for permanent prostate brachytherapy: insights from a multicenter analysis of dosimetry outcomes. *International journal of radiation oncology, biology, physics* 2007;69:1472-7.
  60. Bice WS, Prestidge BR, Kurtzman SM, et al. Recommendations for permanent prostate brachytherapy with (131)Cs: a consensus report from the Cesium Advisory Group. *Brachytherapy* 2008;7:290-6.
  61. Merrick GS, Butler WM, Wallner KE, et al. Variability of prostate brachytherapy pre-implant dosimetry: a multi-institutional analysis. *Brachytherapy* 2005;4:241-51.
  62. SJ F, JC P, CJ K. Do younger men have better biochemical outcomes after radical prostatectomy? *Urology* 2004;63:518-22.
  63. Butler WM, Stewart RR, Merrick GS. Evaluation of radiobiologic biochemical control in a large permanent prostate brachytherapy population from a single institution using AAPM TG-137 parameters. *Brachytherapy* 2011;10:16-28.
  64. Stock RG, Stone NN, Cesaretti JA, Rosenstein BS. Biologically effective dose values for prostate brachytherapy: effects on PSA failure and posttreatment biopsy results. *International journal of radiation oncology, biology, physics* 2006;64:527-33.
  65. Wallner K, Merrick G, True L, Cavanagh W, Simpson C, Butler W. I-125 versus Pd-103 for low-risk prostate cancer: morbidity outcomes from a prospective randomized multicenter trial. *Cancer J* 2002;8:67-73.
  66. Benoit RM, Smith RP, Beriwal S. Five year prostate-specific antigen outcomes after caesium prostate

- brachytherapy. *Clin Oncol (R Coll Radiol)* 2014;26:776-80.
67. Blanchard P, Pugh TJ, Swanson DA, et al. Patient-reported health-related quality of life for men treated with low-dose-rate prostate brachytherapy as monotherapy with 125-iodine, 103-palladium, or 131-cesium: Results of a prospective phase II study. *Brachytherapy* 2018;17:265-76.
  68. Merrick GS, Butler WM, Wallner KE, Lief JH, Galbreath RW. Prophylactic versus therapeutic alpha-blockers after permanent prostate brachytherapy. *Urology* 2002;60:650-5.
  69. American College of Radiology. ACR-ARS practice parameter for communication: radiation oncology. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Communication-RO.pdf?la=en>. Accessed June 26, 2019.
  70. Dubois DF, Prestidge BR, Hotchkiss LA, Bice WS, Jr., Prete JJ. Source localization following permanent transperineal prostate interstitial brachytherapy using magnetic resonance imaging. *International journal of radiation oncology, biology, physics* 1997;39:1037-41.
  71. Moerland MA, Wijrdeman HK, Beersma R, Bakker CJ, Battermann JJ. Evaluation of permanent I-125 prostate implants using radiography and magnetic resonance imaging. *International journal of radiation oncology, biology, physics* 1997;37:927-33.
  72. Frank SJ, Mourtada F, Crook J, Menard C. Use of magnetic resonance imaging in low-dose-rate and high-dose-rate prostate brachytherapy from diagnosis to treatment assessment: Defining the knowledge gaps, technical challenges, and barriers to implementation. *Brachytherapy* 2017;16:672-78.
  73. Prestidge BR, Bice WS, Kiefer EJ, Prete JJ. Timing of computed tomography-based postimplant assessment following permanent transperineal prostate brachytherapy. *International journal of radiation oncology, biology, physics* 1998;40:1111-5.
  74. Yue N, Dicker AP, Nath R, Waterman FM. The impact of edema on planning 125I and 103Pd prostate implants. *Medical physics* 1999;26:763-7.
  75. Davis BJ, Bresnahan JF, Stafford SL, Karon BL, King BF, Wilson TM. Prostate brachytherapy seed migration to a coronary artery found during angiography. *The Journal of urology* 2002;168:1103.
  76. Orio PF, 3rd, Merrick GS, Grimm P, et al. Effects of the time interval between prostate brachytherapy and postimplant dosimetric evaluation in community practice: analysis of the Pro-Qura database. *American journal of clinical oncology* 2008;31:523-31.
  77. Tausky D, Yeung I, Williams T, et al. Rectal-wall dose dependence on postplan timing after permanent-seed prostate brachytherapy. *International journal of radiation oncology, biology, physics* 2006;65:358-63.
  78. Waterman FM, Yue N, Reisinger S, Dicker A, Corn BW. Effect of edema on the post-implant dosimetry of an I-125 prostate implant: a case study. *International journal of radiation oncology, biology, physics* 1997;38:335-9.
  79. Nath R, Bice WS, Butler WM, et al. AAPM recommendations on dose prescription and reporting methods for permanent interstitial brachytherapy for prostate cancer: report of Task Group 137. *Medical physics* 2009;36:5310-22.
  80. Yu Y, Anderson LL, Li Z, et al. Permanent prostate seed implant brachytherapy: report of the American Association of Physicists in Medicine Task Group No. 64. *Medical physics* 1999;26:2054-76.
  81. Merrick GS, Butler WM, Dorsey AT, Walbert HL. Influence of timing on the dosimetric analysis of transperineal ultrasound-guided, prostatic conformal brachytherapy. *Radiation oncology investigations* 1998;6:182-90.
  82. Willins J, Wallner K. Time-dependent changes in CT-based dosimetry of I-125 prostate brachytherapy. *Radiation oncology investigations* 1998;6:157-60.
  83. Roberson PL, McLaughlin PW, Narayana V, Troyer S, Hixson GV, Kessler ML. Use and uncertainties of mutual information for computed tomography/ magnetic resonance (CT/MR) registration post permanent implant of the prostate. *Medical physics* 2005;32:473-82.
  84. Dubois DF, Prestidge BR, Hotchkiss LA, Prete JJ, Bice WS, Jr. Intraobserver and interobserver variability of MR imaging- and CT-derived prostate volumes after transperineal interstitial permanent prostate brachytherapy. *Radiology* 1998;207:785-9.
  85. Lee WR, Roach M, 3rd, Michalski J, Moran B, Beyer D. Interobserver variability leads to significant differences in quantifiers of prostate implant adequacy. *International journal of radiation oncology, biology, physics* 2002;54:457-61.
  86. Nag S. Brachytherapy for prostate cancer: summary of American Brachytherapy Society recommendations. *Seminars in urologic oncology* 2000;18:133-6.

87. Nag S, Beyer D, Friedland J, Grimm P, Nath R. American Brachytherapy Society (ABS) recommendations for transperineal permanent brachytherapy of prostate cancer. *International journal of radiation oncology, biology, physics* 1999;44:789-99.
88. Nag S, Bice W, DeWyngaert K, Prestidge B, Stock R, Yu Y. The American Brachytherapy Society recommendations for permanent prostate brachytherapy postimplant dosimetric analysis. *International journal of radiation oncology, biology, physics* 2000;46:221-30.
89. Davis BJ, Horwitz EM, Lee WR, et al. American Brachytherapy Society consensus guidelines for transrectal ultrasound-guided permanent prostate brachytherapy. *Brachytherapy* 2012;11:6-19.
90. Davis BJ, Taira AV, Nguyen PL, et al. ACR appropriateness criteria: Permanent source brachytherapy for prostate cancer. *Brachytherapy* 2017;16:266-76.
91. Kollmeier MA, Stock RG, Stone N. Biochemical outcomes after prostate brachytherapy with 5-year minimal follow-up: importance of patient selection and implant quality. *International journal of radiation oncology, biology, physics* 2003;57:645-53.
92. Lee WR, Bae K, Lawton CA, et al. A descriptive analysis of postimplant dosimetric parameters from Radiation Therapy Oncology Group P0019. *Brachytherapy* 2006;5:239-43.
93. Potters L, Cao Y, Calugaru E, Torre T, Fearn P, Wang XH. A comprehensive review of CT-based dosimetry parameters and biochemical control in patients treated with permanent prostate brachytherapy. *International journal of radiation oncology, biology, physics* 2001;50:605-14.
94. Stock RG, Stone NN, DeWyngaert JK, Lavagnini P, Unger PD. Prostate specific antigen findings and biopsy results following interactive ultrasound guided transperineal brachytherapy for early stage prostate carcinoma. *Cancer* 1996;77:2386-92.
95. Zelefsky MJ, Kuban DA, Levy LB, et al. Multi-institutional analysis of long-term outcome for stages T1-T2 prostate cancer treated with permanent seed implantation. *International journal of radiation oncology, biology, physics* 2007;67:327-33.
96. Merrick GS, Butler WM, Wallner KE, et al. The impact of radiation dose to the urethra on brachytherapy-related dysuria. *Brachytherapy* 2005;4:45-50.
97. Sherertz T, Wallner K, Merrick G, et al. Factors predictive of rectal bleeding after 103Pd and supplemental beam radiation for prostate cancer. *Brachytherapy* 2004;3:130-5.
98. Tran A, Wallner K, Merrick G, et al. Rectal fistulas after prostate brachytherapy. *International journal of radiation oncology, biology, physics* 2005;63:150-4.
99. Merrick GS, Butler WM, Wallner KE, et al. The importance of radiation doses to the penile bulb vs. crura in the development of postbrachytherapy erectile dysfunction. *International journal of radiation oncology, biology, physics* 2002;54:1055-62.
100. Solan AN, Cesaretti JA, Stone NN, Stock RG. There is no correlation between erectile dysfunction and dose to penile bulb and neurovascular bundles following real-time low-dose-rate prostate brachytherapy. *International journal of radiation oncology, biology, physics* 2009;73:1468-74.
101. Pfeiffer D, Sutlief S, Feng W, Pierce HM, Kofler J. AAPM Task Group 128: quality assurance tests for prostate brachytherapy ultrasound systems. *Medical physics* 2008;35:5471-89.
102. American College of Radiology. ACR–AAPM technical standard for diagnostic medical physics performance monitoring of real time ultrasound equipment. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/US-Equip.pdf?la=en>. Accessed June 26, 2019.
103. Kutcher GJ, Coia L, Gillin M, et al. Comprehensive QA for radiation oncology: report of AAPM Radiation Therapy Committee Task Group 40. *Medical physics* 1994;21:581-618.
104. Rivard MJ, Coursey BM, DeWerd LA, et al. Update of AAPM Task Group No. 43 Report: A revised AAPM protocol for brachytherapy dose calculations. *Medical physics* 2004;31:633-74.
105. Nath R, Anderson LL, Meli JA, Olch AJ, Stitt JA, Williamson JF. Code of practice for brachytherapy physics: report of the AAPM Radiation Therapy Committee Task Group No. 56. *American Association of Physicists in Medicine. Medical physics* 1997;24:1557-98.
106. Butler WM, Bice WS, Jr., DeWerd LA, et al. Third-party brachytherapy source calibrations and physicist responsibilities: report of the AAPM Low Energy Brachytherapy Source Calibration Working Group. *Medical physics* 2008;35:3860-5.
107. American College of Radiology. ACR–ARS practice parameter for radiation oncology. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/RadOnc.pdf?la=en>. Accessed June 26, 2019.
108. Kuban DA, Levy LB, Potters L, et al. Comparison of biochemical failure definitions for permanent prostate

Revised 2020 (CSC/BOC) International journal of radiation oncology, biology, physics 2006;65:1487-93.

109. Roach M, 3rd, Hanks G, Thames H, Jr., et al. Defining biochemical failure following radiotherapy with or without hormonal therapy in men with clinically localized prostate cancer: recommendations of the RTOG-ASTRO Phoenix Consensus Conference. International journal of radiation oncology, biology, physics 2006;65:965-74.
110. Morris WJ, Pickles T, Keyes M. Using a surgical prostate-specific antigen threshold of >0.2 ng/mL to define biochemical failure for intermediate- and high-risk prostate cancer patients treated with definitive radiation therapy in the ASCENDE-RT randomized control trial. Brachytherapy 2018;17:837-44.
111. Bostancic C, Merrick GS, Butler WM, et al. Isotope and patient age predict for PSA spikes after permanent prostate brachytherapy. International journal of radiation oncology, biology, physics 2007;68:1431-7.
112. Cavanagh W, Blasko JC, Grimm PD, Sylvester JE. Transient elevation of serum prostate-specific antigen following (125)I/(103)Pd brachytherapy for localized prostate cancer. Seminars in urologic oncology 2000;18:160-5.
113. Critz FA, Williams WH, Benton JB, Levinson AK, Holladay CT, Holladay DA. Prostate specific antigen bounce after radioactive seed implantation followed by external beam radiation for prostate cancer. The Journal of urology 2000;163:1085-9.

\*As of May 2010, all radiation oncology collaborative parameters are approved by the ACR Council Steering Committee and the ACR Board of Chancellors and will not go through the ACR Council (ACR Resolution 8, 2010). The effective date is displayed below:

#### Development Chronology for this Practice Parameter

2000 (Resolution 19)

Revised 2005 (Resolution 19)

Amended 2006 (Resolution 16g, 36)

Revised 2010 (Resolution 2)

Amended 2014 (Resolution 39)

Revised 2015 (CSC/BOC)

Revised 2020 (CSC/BOC)

Amended 2023 (Resolution 2c)