Prostate cancer is the most common cancer in men after skin cancer. Incidence rates and mortality rates for prostate cancer vary based on several demographic factors, including age, ethnic group, geographic location, and socioeconomic status. This article discusses common treatment options and focuses on prostate brachytherapy with particular attention paid to the tasks involved in successfully completing the implant procedure. The possible roles of the radiation therapist as a member of the prostate seed implant team also are explored.

**Prostate Brachytherapy**

Gary N Poteat, MS, DABR

*After completing this article, the reader should be able to:*
- Describe variations in the incidence and mortality rates for prostate cancer.
- Specify methods used to screen for prostate cancer and discuss the advantages and disadvantages of prostate cancer screening.
- Explain how prostate cancer is diagnosed.
- List treatment options for localized disease.
- Discuss the seeds and equipment used for prostate brachytherapy.
- Describe the implant procedure.
- Explain the radiation therapist’s possible roles in prostate brachytherapy.
- Discuss adverse effects associated with prostate brachytherapy and summarize research findings on treatment outcomes.

Prostate cancer is the most common cancer among men other than skin cancer. In the United States, prostate cancer is the second leading cause of cancer death in men, behind lung cancer.1 The American Cancer Society estimated more than 233,000 new cases of prostate cancer will be diagnosed in 2014 in the United States, with more than 29,000 deaths expected this year.1 Prostate cancer accounts for approximately 27% of all newly diagnosed cancers and approximately 10% of cancer deaths.1 Statistics indicate that this disease progresses relatively slowly compared with other cancers and can be treated effectively. In contrast, lung and bronchus cancers account for 13% of estimated new cancer diagnoses, but these cancers are responsible for the highest percentage of estimated cancer deaths for men (28%).1

Patients with metastatic disease present at the time of prostate cancer diagnosis have a 5-year survival rate of 28%. However, patients who receive a diagnosis including only local disease or regional spread of prostate cancer have a 5-year survival rate of 100%. The 5-year survival rate for all stages of prostate cancer combined is 99%. In comparison, patients with a diagnosis of lung or bronchus cancer at any stage have a 5-year survival rate of 17%.1

The most important risk factor for prostate cancer is age.1 The median age for developing prostate cancer in the United States is 66 years. However, prostate cancer is not a disease of the elderly; half of prostate cancers are diagnosed before age 68. The probability of being diagnosed with prostate cancer increases from 1 in 43 (2.3%) for a 50-year-old cancer-free man to 1 in 9 (11.2%) for a 70-year-old cancer-free man.1
Prostate cancer incidence and mortality both show significant variation by ethnicity, geographic region, and socioeconomic status. For example, in the United States, incidence of prostate cancer is 60% higher in African American men than in non-Hispanic whites, and the mortality rate for African Americans is twice as high as any other group (see Table 1). Some of this variability is socioeconomic; however, some variability appears to arise from other sources, such as genetics.

Geographic variation in both incidence and mortality are pronounced. Among white men in the United States, incidence is highest in northern states. Among African American men, incidence is highest in the Southeast. Mortality rates follow similar patterns. Internationally, incidence rates vary by a factor of 50, with North America, Australia, and northern and central Europe showing the highest incidence. Southeastern and South Central Asia and Northern Africa have the lowest incidence. Although some of this variation is due to differences in screening frequency, as is the case with different socioeconomic groups in the United States, other factors also are involved. Prostate cancer mortality rates are high in some less wealthy nations (eg, Barbados), as well as in certain wealthy nations, (eg, Sweden and Norway). The causes of these variations appear to be complex and likely include genetics, screening, social factors, and treatment factors that are difficult to separate.

In the United States, socioeconomic status affects both incidence and mortality rates. For example, among white men, incidence increases with a college education and is lowest among men who did not complete high school. However, the likelihood of having advanced disease at the time of diagnosis is reversed, with men who did not complete high school more likely to have advanced disease when diagnosed. These differences in incidence and disease status appear to be a result of differences in screening among socioeconomic groups. Although availability of screening and education on its importance are public health issues that deserve attention, the effectiveness of prostate cancer screening is somewhat controversial.

Screening

In its early stages, prostate cancer has no symptoms. As it progresses, symptoms might include difficulty urinating, pain or burning during urination, or blood in the urine (hematuria). Some of these symptoms are common in older men as a result of other causes, and none are specific to prostate cancer. In advanced cases, prostate cancer often spreads to the bones, causing pain. The 2 principal screening methods for prostate cancer are the prostate-specific antigen (PSA) blood test and the digital rectal examination (DRE). PSA is a protein normally present in small amounts in the blood. Elevated levels of PSA can indicate prostate cancer. However, PSA can be elevated by other, nonmalignant conditions such as benign prostatic hyperplasia. A blood test for PSA was approved by the U.S. Food and Drug Administration in 1986. The PSA test is more sensitive than the DRE, but the PSA test was approved for use in conjunction with the DRE because the 2 tests are complementary. A prospective clinical trial of 6630 men aged older than 50 years was conducted in the United Kingdom to compare PSA testing and the DRE. The cancer detection rate was higher for both tests combined than for either test alone. However, the PSA test has significant rates of false-positive and false-negative results.

Certainly, the use of the PSA test has increased the diagnosis of prostate cancer, including overdiagnosis. Overdiagnosis is diagnosis of prostate cancer as a result of screening that would never progress to symptoms.

Table 1

<table>
<thead>
<tr>
<th>Race or Ethnicity</th>
<th>Incidence</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>African American</td>
<td>220.0</td>
<td>50.9</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>138.6</td>
<td>21.3</td>
</tr>
<tr>
<td>Hispanic or Latino</td>
<td>124.2</td>
<td>19.2</td>
</tr>
<tr>
<td>American Indian or Alaska Native</td>
<td>104.1</td>
<td>20.7</td>
</tr>
<tr>
<td>Asian American or Pacific Islander</td>
<td>75.0</td>
<td>10.1</td>
</tr>
</tbody>
</table>

Rates are per 100 000 population and age adjusted to the 2000 U.S. standard population.

Mortality rates for Hispanics and non-Hispanic whites exclude deaths from the District of Columbia, North Dakota, and South Carolina.

Data based on Indian Health Service Contract Health Service Delivery Areas.
or death during the patient’s lifetime. Overdiagnosis results in unnecessary financial costs for society and can cause added morbidity for patients because of treatment. The result is an ongoing argument over the costs of overdiagnosis vs benefits of earlier diagnosis of cancer from widespread screening using the PSA test.

Two large clinical trials were undertaken to determine whether screening for prostate cancer reduces patient mortality. The U.S. Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial involved 77,000 men aged 55 to 74 years; the European Randomized Study of Screening for Prostate Cancer involved 182,000 men aged 54 to 69 years. The U.S. trial showed no mortality benefit to screening. However, 56% of the men in the control group for the U.S. trial (ie, the group not being screened every year with a PSA test) had one or more PSA tests during the 8-year study. Therefore, this study has been described as “a comparison of annual screening vs intermittent screening.”

Conversely, the European trial showed a 20% reduction in mortality for men undergoing routine PSA screening. However, results from the European trial do not eliminate criticism of PSA screening. The authors argued that the “average man who chooses screening decreases his risk of prostate cancer death from a lifetime risk of 3% to a lifetime risk of 2.4%. In exchange, he increases his risk of diagnosis from between 6%-9% to at least 17%.” American Cancer Society recommendations acknowledge this controversy and concluded that “clinical policies that avoid discussing testing, discourage testing, or recommend testing to all men were inappropriate.” Ultimately, the decision to use PSA screening should be made by a physician and a patient on an individual basis.

Differentiating between cancers posing significant vs minimal risk and reducing treatment of low-risk disease should be a goal. Esserman et al noted that incidence of prostate cancer increased after the introduction of screening but has not returned to prescreening levels, and more early-stage cancers are being detected. In addition, the incidence of regional cancers has not decreased proportionately as a result of screening. One explanation the authors provided is that screening might be increasing the burden of low-risk cancers while not reducing the burden of more aggressive cancers. Therefore, screening is not reducing cancer mortality as anticipated. Reducing overdiagnosis and reducing mortality will require more research and patient education, but the most difficult issues are differentiating between high-risk and low-risk cancers at diagnosis and making the decision not to treat cancers that were overdiagnosed.

In May 2012, the U.S. Preventative Services Task Force recommended against any PSA-based screening for prostate cancer for men of any age. This recommendation was largely based on the U.S. Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial and the European Randomized Study of Screening for Prostate Cancer. Criticism of the recommendation against screening for prostate cancer using PSA included the length of follow-up used in the clinical trials, the degree of “contamination” from off-protocol PSA testing of the control group, and the lack of physicians in prostate cancer–related medical specialties on the task force. The debate concerning screening with the PSA test is only beginning.

The incidence of prostate cancer has changed significantly since 1975, with a dramatic increase after the introduction of the PSA test in 1986 (see Box). The increase in prostate cancer incidence between 1988 and 1992 is widely thought to be a result of PSA screening. However, the decline in incidence since 1992 is not as well understood. A review of breast cancer showed a similar pattern of increased incidence following the introduction of mammography screening in the early 1980s and a subsequent decrease in incidence years later.

**Box**

**Trends in Prostate Cancer Incidence and Mortality**

**Incidence**
- 1975 to 1988 – 2.6% increase.
- 1988 to 1992 – 16.5% increase.
- 1995 to 2000 – stable (0% change each year).
- 2000 to 2006 – 2.4% decrease.

**Mortality**
- 1975 to 1987 – 0.9% increase.
- 1987 to 1991 – 3.0% increase.
- 1991 to 1994 – stable (0% change each year).
- 1994 to 2006 – 4.1% decrease.
In addition, a significant increase in mortality rates between 1987 and 1991 was recorded. However, the increase in mortality rates could be explained by attribution bias. Attribution bias occurs when a death is ascribed to one cause even though multiple factors are present. The focus on prostate cancer during the years the PSA test was introduced might have contributed to attribution bias, resulting in the appearance of increased mortality from prostate cancer.

Over time, the increase in incidence as a result of a new screening technology would be expected to decline because the initial large group of nonsymptomatic cancers found by the new screening test would have been identified. Thus, screening would then reveal new cancers at a rate proportional to the population’s rate of incidence of the cancer and the fraction of the population being screened. However, mortality rates should decrease over time as cancers are diagnosed at an earlier stage. The decrease in mortality is evident; however, it has been argued that improvements in treatment, rather than screening, are responsible for some portion of the decrease in mortality.

**Diagnosis**

The prostate is a walnut-sized gland located between the bladder and the penis, lying anterior to the rectum (see Figure 1). The prostate consists of 30 to 50 tubular glands that secrete and store fluid that is a major constituent of seminal fluid. These glands are surrounded by interstitial tissues such as muscle and elastic and collagen fibers that support the glands. In addition, the prostate is enclosed in a capsule of interstitial tissues. Prostate cancer is an adenocarcinoma, a cancer that originates in the cells of the glands.

If a PSA test and a DRE indicate that a patient might have prostate cancer, a core-needle biopsy of the prostate typically is performed, usually as an outpatient procedure under local anesthetic. The biopsy specimens can be collected through the rectal wall, perineum, or urethra. Either digital or ultrasound guidance is used for needle placement. Usually, 12 biopsy samples (6 per prostate lobe) are collected. A pathologist then examines the tissue samples for cancerous cells.

In some cases, the biopsy reveals prostatic intraepithelial neoplasia. High-grade prostatic intraepithelial neoplasia cells are a possible precursor to prostate cancer and are associated with cancerous cells 85% of the time. However, a prostate biopsy provides only a sample of prostate tissue, so a false-negative biopsy is possible, and repeat biopsies could be ordered. Studies have shown that 23% or more of initial prostate biopsies yield false-negative results.

If cancer is present, the pathologist assigns a grade or a score based on the microscopic appearance of the cancer cells. The Gleason tumor grade system is commonly used to score tumor patterns seen on a biopsy. The pathologist assigns a score ranging from 1 to 5 to the 2 most common tumor patterns identified. The 2 scores are added to obtain the Gleason score. The higher the score, the more likely the cancer is to spread (see Table 2).

Prostate cancer metastasizes when cancer cells invade surrounding tissues or are transported by the lymphatic system or bloodstream. After prostate cancer is diagnosed, a variety of tests can be used to determine the stage

<table>
<thead>
<tr>
<th>Score</th>
<th>Grade and Aggressiveness</th>
</tr>
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<tbody>
<tr>
<td>6</td>
<td>Low-grade cancer, mildly aggressive</td>
</tr>
<tr>
<td>7</td>
<td>Medium-grade cancer, moderately aggressive</td>
</tr>
<tr>
<td>8-10</td>
<td>High-grade cancer, highly aggressive</td>
</tr>
</tbody>
</table>

Figure 1. Prostate and surrounding structures.
of the cancer. Bone scans, magnetic resonance (MR) imaging scans, computed tomography (CT) scans, pelvic lymphadenectomy, seminal vesicle biopsy, and blood tests all can aid in cancer staging. Cancer staging systems vary, and the treatment recommended depends on the cancer stage at diagnosis and the clinical judgment of the physician. The American Joint Committee on Cancer and the Union for International Cancer Control developed the TNM staging system, in which T describes the extent of the tumor, N the nodal involvement, and M any metastatic activity.

To see the TNM staging system in more detail click here in the online version of this article.

Treating Localized Prostate Cancer

Because of overdiagnosis concerns, active surveillance occurs prior to treatment. Active surveillance is ongoing monitoring of the patient with the intention of intervening with treatment in the future, if necessary. Monitoring consists of periodic PSA tests, DREs, and, in some cases, additional biopsies.

If deemed necessary, several treatment options are available for localized prostate cancer. Androgen deprivation therapy, commonly known as hormone therapy, involves chemical or surgical castration, antiandrogen medication, or a combination of these. Cryoablation is another treatment option. During cryoablation treatment, probes are inserted into the prostate using transrectal ultrasound (TRUS) guidance. Freezing and thawing gases are channeled into the probes, and cells are killed using a controlled cycle of freezing and thawing.

External-beam radiation therapy (EBRT) techniques include intensity-modulated radiation therapy, conformal (or 3-D) radiation therapy, and proton radiation therapy. High-intensity focused ultrasound therapy is a type of hyperthermia treatment that uses focused ultrasound to heat and kill cells. Surgical removal of the prostate, seminal vesicles, ampulla of vas deferens (see Figure 1), and, in some cases, lymph nodes is performed using traditional open surgery, laparoscopic surgery, and robotic surgical methods. In addition, 2 types of brachytherapy are used in the treatment of prostate cancer. The most common type is permanent implantation of low-activity radioactive sources (or “seeds”), which are placed using needles inserted through the perineum and guided by TRUS. This technique typically uses 70 to 120 1-mm × 5-mm seeds (see Figure 2).

Less common is the use of high-dose-rate remote afterloaders to give one to several fractions of interstitial brachytherapy. After imaging and treatment planning, the patient is treated using a high-dose-rate afterloader, which delivers the radiation using temporarily implanted radioactive material (see Figure 3). The treatment plan designates multiple locations within the prostate to be irradiated for a limited amount of time, ensuring adequate coverage of the target volume. Closed-end needles are inserted in a manner and pattern similar to permanent implants, and the needles are replaced by catheters. The catheters allow a small radioactive source
to be passed into the prostate. The catheters are attached to the afterloader with transfer tubes, and the radiation is delivered. Once each point has received the radiation for the predetermined length of time, the radioactive source is removed from the patient after each treatment.25

Because no clinical trials comparing these treatments exist, patient and physician preference determine which treatment or combination of treatments are used.27 Despite the lack of consensus on the best treatment, many modalities have been used successfully to treat locally confined prostate cancer. The only differences between the treatments are the type and severity of adverse effects and complications.26 Targeting the men most likely to need intervention to prevent prostate cancer death and disability while simultaneously limiting treatment-related complications is a challenge.27 Despite recent emphasis on minimizing overtreatment, insufficient data exist to confidently identify particular patients as having low-, intermediate-, or high-risk tumors.27 In all cases, a multidisciplinary team chooses the treatment approach after carefully considering several patient-specific factors.

**Permanent Implant Brachytherapy**

A variety of materials and equipment is used for low-dose-rate (LDR) brachytherapy, including radiopharmaceuticals, seed types, and TRUS. For the purposes of this article, the term **permanent seed implant** will be used for this procedure.

**Radiopharmaceuticals and Seed Types**

Prostate brachytherapy uses a variety of radiopharmaceuticals and seed designs from multiple manufacturers. Traditionally, the isotopes used were iodine 125 and palladium 103; seeds containing cesium 131 were introduced in 2004.28 Although limited research has been published advocating one radiopharmaceutical in favor of another, arguments have been made for using shorter half-life seeds to treat faster growing, more aggressive tumors because the dose from short half-life seeds is deposited more rapidly.29 The physician’s prescription typically specifies the type of seed to be used for the treatment plan. Selection of seed type for permanent implantation is based on clinician and institutional preference.30

All permanent implant seeds are cylindrical and measure approximately 4.5 mm long and 0.8 mm in diameter. The details of a seed’s external shape, its internal structure, and cladding (covering) material vary by seed manufacturer and model. Some manufacturers produce multiple models of seeds for the same isotope. The dose distribution for each model of implant seed is unique to that isotope and model. This is because the internal structure and the thickness and type of metal used for the cladding can affect dose distribution around the seed. Therefore, dosimetric data must be included in the treatment planning system for the particular seed type to be used. Details of seed design and dosimetric data are widely available in the literature.31

The half-life and energy of photon emissions from permanent implant seeds are independent of the seed’s physical design. Iodine 125 has a half-life of approximately 60 days and emits photons with an average energy of approximately 27 keV. Palladium 103 has a half-life of 17 days, and the approximate energy of photons emitted is 23 keV. Cesium 131 has a half-life of 9.7 days and an energy of photon emissions of 29 keV.28

The half-life of the isotope used determines how quickly the dose is deposited in the prostate. The shorter the half-life of the isotope in the seed, the quicker the dose is deposited. For example, 90% of the dose is delivered in 197 days using iodine 125 vs 56 days using palladium 103.35

**Equipment**

Transrectal Ultrasound

The equipment used for permanent seed implantation typically is a specialized ultrasound unit designed for that purpose. It is equipped with a TRUS probe that can, in most cases, image axially or sagittally using separate ultrasound crystals. Both sagittal and axial images are helpful in imaging anatomical features as well as needle and seed locations.34

The TRUS probe is mounted on a “stepper” unit that holds it securely and accurately moves the probe when a knob on the stepper turns (see Figure 4). Each click of the stepper apparatus moves the TRUS probe crystal and the ultrasound image 5 mm. A needle template also is mounted on the stepper unit. The template usually has 13 rows of holes and 13 columns of holes sized for needles. Each column and row has a designation engraved on the template (eg, rows are designated 1, 1.5, 2, 2.5, etc, and columns are designated A, a, B, b, etc) (see Figure 5). Overlaid on the patient image, the ultrasound unit displays a grid pattern...
duplication of the position of the prostate and other anatomy.\textsuperscript{32} Matching the patient’s anatomy from the volume study during the implant procedure is crucial to minimize uncertainties in delivering the implants as described in the treatment plan.\textsuperscript{32}

In 2-step preoperative dosimetric planning, the equipment is moved from the procedure room (where the volume study is performed) to the operating room (where the implantation occurs). Several smaller items, such as special cables that allow the transfer of images between the TRUS unit and the treatment planning computer, also must be moved. In intraoperative planning, however, the steps are combined: The patient is anesthetized, and the volume study is performed. The physicist and radiation oncologist review a computer-generated optimized dosimetric plan, and seed implantation takes place.\textsuperscript{32}

Preloaded Needles

Implant needles used for preloading come in several styles and lengths, but 17- or 18-gauge needles are typical. The sharp, beveled tips of the needles produce a strong ultrasound signal.\textsuperscript{33} The other end of the needle has a plastic hub attached (see \textbf{Figure 6}). To minimize radiation exposure to the fingers, the needle always is handled by this hub, especially after seeds have been loaded into the needle. The needle is intended to be “steerable” in tissue, meaning that a physician can change the needle’s direction slightly by turning the needle bevel or applying slight lateral pressure between the needle template and the perineum with a metal ruler or similar object.\textsuperscript{33}
Traditionally, seeds were loaded on site into the implant needles following the pattern shown on the treatment plan. Because seeds are not normally loaded back to back, spaces between seeds were created using 5-mm pieces of absorbable suture. Unfortunately, upon removal of the needle, loose seeds could be dragged out of their intended position. Loose seeds can migrate within the prostate or, via the venous system, into the pelvis, lungs, and, on at least one occasion, the coronary artery.

Seeds also can be embedded in a continuous piece of flexible, sterile suture material, creating a strand of seeds in a pattern customized to match the patient’s treatment plan (see Figure 7). The use of these “stranded” seeds can reduce seed migration outside and within the prostate. In addition, some authors assert that the use of stranded seeds results in improved implantations that more closely match the treatment plan. However, others argue that stranded seeds are displaced by edema, which results in higher doses than planned in the center of the prostate and lower doses at the base and apex of the prostate.

The tip of the needle is kept closed by a temporary plug of bone wax, plastic, or rectal suppository material to prevent the seeds from falling out of the needle tip prior to implantation. A stylet is inserted into the needle from the hub end to prevent seeds from falling out of that end. This stylet can extend up to several centimeters past the hub after seeds are loaded, depending on how many seeds and spacers are loaded in the needle. Great care should be taken not to press on the stylet because the plug and seeds can be expelled from the needle with relatively little force. When the needle is inserted into the patient, the physician exerts pressure on the hub only. Once the needle is in the correct location and its location is verified using ultrasound images, the stylet is held in place, and the needle is withdrawn. The stylet keeps the seeds in place while the needle is withdrawn, thus depositing the seeds in the correct location (see Figure 8).

In the early days of permanent seed implantation, all needles were loaded on site under sterile conditions immediately prior to implantation. If desired, this can still be done. Even stranded seeds can be loaded on site. However, some implanting centers now use needles loaded at special nuclear pharmacies that arrive ready to implant. The center can specify whether the needles will be loaded using loose spacers or stranded seeds. A needle-loading diagram, which is generated by the treatment planning system, is submitted to the seed manufacturer with the seed order. The seed manufacturer provides the loading diagram, along with seeds of the appropriate activity, to the pharmacy. The pharmacy assays the seed activity; loads the needles according to the treatment plan; autoradiographs the needles; etc.

Figure 7. Nonradioactive example of the seeds, suture material, and the tip of an implant needle (A). A strand of dummy seeds (B) placed alternately between the suture material spacers (C). Image courtesy of Gary Poteat.

Figure 8. Illustration demonstrating placement of the TRUS probe and template, as well as the needle with seeds, spacers, and stylet.
Comparing Treatment Planning Techniques

Comparing the efficacy of permanent seed implant techniques is difficult because no clinical trials of the techniques with large numbers of patients have been performed. Each technique has advocates and, historically, most clinical experience has been with preplanning, which results in excellent outcomes if done well. However, advocates of intraoperative treatment planning cite difficulties in reproducing the patient setup used during the preplanning volume study during the actual implant procedure and the advantage of being able to adjust the treatment plan during the procedure.37

Advocates of preplanning point out that the pressure of preparing a complex treatment plan in the operating room with a patient under anesthesia and a large group of staff members waiting encourages mistakes and discourages a thorough review of the treatment plan, extended discussion between members of the implant team, and careful consideration of alternatives. They also argue that preplanning uses expensive resources such as operating room and staff time efficiently. Seeds are used efficiently because all the seeds ordered after preplanning are typically implanted.38 Interactive treatment planning and dynamic dose calculation also have strong advocates.38 Thus, the debate regarding which of these 4 approaches is optimal is ongoing.

Implant Team

The composition of the permanent seed implant team varies widely among facilities. The American Brachytherapy Society defines 4 approaches to treatment planning for brachytherapy29:

- Preplanning – the treatment plan is prepared outside the operating room days or weeks prior to implantation based on ultrasound images collected during the volume study.
- Intraoperative – the treatment plan is prepared in the operating room using ultrasound images collected during the volume study. The patient is not moved while the treatment plan is prepared.
- Interactive – a preplanned treatment plan or intraoperative plan is revised periodically during implantation using ultrasound images of seed positions.
- Dynamic dose calculation – the dose distribution is continuously updated as seeds are implanted using ultrasound images of seed positions. Placement of seeds can be altered during implantation based on the real-time dose distribution.

Mick Seed Applicator

Using a Mick seed applicator (Eckert and Ziegler BEBIG) is an alternative to preloaded needles. The seeds arrive from the manufacturer in sterilized or sterilizable cartridges containing 10 or more seeds. The needle attached to the Mick applicator body is inserted into the prostate using the same template used for preloaded needles to ensure proper axial positioning (see Figure 9). The needle is inserted to the depth specified in the treatment plan, and seeds are fed from the cartridge into the needle, one-by-one, and placed in the prostate at a location specified in the treatment plan. The needle tip is then moved to the next location, and another seed is dropped until all the seeds have been placed.36

Figure 9. Mick applicator. Image courtesy of Gary Poteat.

packages the needles in a shielded, sterile container; and ships the needles, ready for implant, to the implanting center. The pharmacy provides autoradiograph and assay results to the implanting center for verification that the needles were loaded correctly and that the seeds are the correct activity. The institution can re-assay the needles or re-autoradiograph them if necessary.32
College of Radiology practice guidelines recommend the following staff for permanent prostate seed implantation:

- Radiation oncologist.
- Medical physicist.
- Radiation therapist.
- Medical dosimetrist.
- Patient support staff.

The radiation therapist is responsible for patient positioning, performing CT scanning, scheduling, setting up treatment aids, and educating patients. Other tasks such as operating room techniques, use of the ultrasound unit, and involvement in treatment planning are of interest to therapists who wish to broaden their knowledge of the procedure. The roles of the therapist described here are for a preplanning approach to permanent seed implantation, but many of the activities are common to other permanent seed implantation techniques.

**Step 1: Imaging**

Permanent seed implantation begins with imaging to determine whether the procedure is appropriate for a particular patient. A CT scan or MR scan of the prostate is often the first step, and sometimes both types of studies are performed. Prostate size and the possibility of pubic arch interference during needle insertion can be evaluated from these studies, so they are used to determine suitability for permanent seed implantation. These studies also help determine whether hormone therapy might be necessary to shrink the prostate prior to seed implantation.

Scheduling the patient, staff, and equipment for the volume study, or TRUS procedure, is a significant administrative task and is sometimes the radiation therapist’s responsibility. The volume study should be performed no earlier than 2 to 3 weeks prior to implantation. In addition, educating the patient about the required preparation and what to expect during the volume study is important to a successful procedure. Education should include instructions for any premedication, dietary or bowel preparation, and other requirements. When the volume study is complete, the radiation therapist should provide patient education about preparation for the seed implant procedure. Instructions for the implant procedure are more extensive than those for the volume study.

Reminding the patient about preparation the day before each procedure can reduce inadequate preparation that could necessitate rescheduling.

The images acquired during the volume study are especially important. Besides determining prostate size and location relative to the pubic arch, the images are used to prepare a treatment plan that will then be used to determine the seed order and establish needle loading and placement. The volume study is necessary because both very large and very small prostates can make implants technically more difficult.

The optimal patient setup for implantation ensures the pubic arch will not impede seed placement. During the volume study, the patient’s position is adjusted until the physician is satisfied the pubic arch will not interfere with the procedure. Proper positioning usually can eliminate pubic arch interference. To provide assurance that the underlying anatomy also matches during the implantation procedure, the same position used for the volume study should be used for implantation.

Setting up the table, stirrups, and the stepper unit to match the implant environment, preparing the TRUS equipment, and inserting the rectal ultrasound probe are important tasks that should be performed or supervised by experienced personnel. Recording equipment settings, such as stirrup position, or taking photographs of the patient setup during the volume study can help reproduce the setup in the operating room. Image transfer between the TRUS unit and the treatment planning system must be verified before the volume study begins.

With the patient in a dorsal lithotomy position and the ultrasound probe mounted on a stepper unit, a series of axial ultrasound images is taken every 5 mm through the entire length of the prostate, sometimes including the seminal vesicles and a 5-mm border above and below the prostate. A sagittal image often is acquired to help ensure axial slices are not omitted or duplicated and to assist in accurate identification of the base and apex.

The TRUS unit overlays the ultrasound images with an image of a grid that corresponds to the template used for needle insertion during implantation (see Figure 10). TRUS units have several types of needle templates in their software, so care must be taken to ensure that the correct template is chosen during setup.
Proper cleaning and sterilization of all equipment is essential following the imaging step because the stepper unit, needle template, and ultrasound probe typically are contaminated with blood, feces, and other bodily fluids during the volume study.

Step 2: Preimplant Treatment Planning

The volume study is the foundation for successful permanent seed implantation, and the importance of limiting differences in setup between the volume study and the implant procedure cannot be overstressed. Differences in prostate volume, shape, and position between the volume study and the operating room often are cited as a rationale for intraoperative treatment planning vs preplanning. The principal causes of these discrepancies are differences in imaging technique, equipment, and patient positioning.

Based on a physician’s prescription, volume study images are used to develop the treatment plan for prostate brachytherapy. The main goals of a treatment plan are to provide the prescribed dose to the entire target volume, ensure rectal and urethral doses are within acceptable limits, and control dose inhomogeneity. The treatment plan also includes the activity and type of radioactive source to be used, number of needles, and precise locations for placement of radioactive seeds within the prostate.

After the ultrasound images are imported into the treatment planning system, the images are registered. The image containing the prostate base normally is designated the “zero” slice, and needle depth is determined relative to the base plane. The treatment planning grid used to decide seed placement is aligned with the needle template grid displayed on the images.

Anatomical or other critical structures specified by the physician must be entered on the ultrasound images by contouring. The contoured structures are used to evaluate whether the treatment plan meets the objectives of the prescription, such as whether the dose to critical structures is low enough. The minimum structures contoured at most institutions are the prostate, rectum, and urethra. Additional structures that might be contoured include the bladder, pubic arch, penile bulb, neurovascular bundles, and tumor loci.

The treatment plan is developed based on a brachytherapy prescription provided by the physician; however, the prescription is distinct from the written directive. According to regulations that apply to all therapeutic uses of radioactive materials regulated by the U.S. Nuclear Regulatory Commission, written directives are required for all permanent prostate seed implants. Details of what the written directive must contain can be found in regulations or in the facility’s radioactive material license. The physician signing the written directive must be listed in the facility’s license as an authorized user for prostate brachytherapy.

The dose used for the treatment plan varies based on the isotope selected (iodine 125, palladium 103, or cesium 131) and whether the treatment is monotherapy (ie, brachytherapy treatment alone) or a combination of brachytherapy and EBRT. Standard doses for prostate brachytherapy are published and widely adhered to. The manufacturer and model of the seed chosen for treatment is also essential information for the planning process because this affects the dosimetric data used for dose calculations.

Treatment planning for permanent seed implants is an iterative process of placing and removing seeds and comparing the dose distribution displayed with the treatment plan objectives. Newer treatment planning software automates the process somewhat, but the task still requires skill and experience to produce a plan that delivers the desired dose coverage to the planning target volume.
A good treatment plan limits the number of needles to minimize trauma from needle insertion and reduce time required for seed implantation and, therefore, the amount of time the patient is under anesthesia. Avoiding needles with a single seed and minimizing back-to-back seeds with no spacers between them also are good techniques. Single-seed needles increase needle trauma with very little effect on the overall dose distribution. Back-to-back seeds might improve the coverage on a treatment plan, especially at the base and apex where it is difficult to plan for adequate dose coverage. However, it is unrealistic to expect seed placement to match the planned placement exactly, so there always is some uncertainty. Therefore, a plan that calls for placing back-to-back seeds near critical structures can result in creating a high-dose region that increases adverse effects instead of improving coverage.

Although uniform and peripheral loading schemas exist for prostate brachytherapy treatment planning, no approach is universally accepted. Prescriptions for prostate brachytherapy are fairly similar, but the details of treatment planning vary widely and make multi-institution comparisons of outcomes and morbidity difficult. These details include drawing target volumes, accomplishing dose homogeneity, maintaining treatment margins, determining seed strengths, and deciding whether seeds are placed outside the prostate.

Usually, prostate brachytherapy planning is less complex than external-beam treatment planning. However, adequate training and support from an experienced physicist or dosimetrist is essential. Radiation therapists included on the implant team should observe several cases being planned to become familiar with prescriptions, the range of treatment plans, and treatment planning reports used to order seeds and perform the implant procedure.

**Step 3: Order and Receipt of Radioactive Seeds**

Based on the treatment plan, seeds must be ordered well in advance of the implant procedure and should be delivered within days of the procedure. Advanced ordering allows time for the manufacturer to prepare and ship the seeds. Seeds can be ordered loose from the manufacturer, and then be sterilized and loaded into needles as specified in the treatment plan, or ordered preloaded in sterile needles from a radiopharmacy ready for implantation. If preloaded needles are used, additional time is required for the radiopharmacy to receive the seeds from the manufacturer and to load the needles prior to shipping.

In addition to dose distributions, the treatment planning system usually provides a loading diagram. This report shows the loading of each needle used in the implant and provides detailed information about the pattern of seeds and spacers, as well as needle depth. The loading diagram is used by an institution if needles are loaded on site or forwarded to the radiopharmacy if preloaded needles are used.

Sometimes, multiple versions of the treatment plan are prepared. Plans using different isotopes, numbers of seeds and needles, and needle-loading diagrams might be formulated prior to selecting a final preplan. Therefore, the radiation therapist should make sure that the final treatment plan approved by the physician is used to prepare the seed order.

After the treatment plan is approved by the physician, ordering seeds is a relatively straightforward process. However, because of the cost of the seeds, ensuring the accuracy of the order is essential. A second person should review the seed order and compare it with the prescription, treatment plan, implant schedule, and the manufacturer’s available source strengths. The facility license should be consulted for detailed regulation requirements for handling radioactive material.

**Step 4: Quality Control**

Prior to the implant procedure, certain quality control tasks should be performed to ensure accurate delivery of the prescribed dose. The manufacturer provides the results of an assay of the seed strength, and if preloaded needles are used, a second assay is performed by the radiopharmacy. However, the institution still is required to obtain an assay report of seed strength. The assay can be done by the medical physicist or other trained personnel designated and supervised by the medical physicist.

Immediately upon receipt of the seeds or preloaded needles, the shipment information should be reviewed and compared with the patient’s treatment plan. If the shipment is not correct, the implant procedure usually is rescheduled. In addition, the treatment plan is compared with the physician’s prescription, and the institution’s
standard practice is performed once again just prior to implantation. If at any point discrepancies are noted, they should be discussed with the implant team.

An institutional assay ensures the activity of the seeds delivered matches the order and verifies the manufacturer’s assay. Autoradiographs of the sterile, loaded needles also might be acquired to document that loading was completed as specified in the treatment plan. If a radiopharmacy is used, it often will provide a second assay report, the manufacturer’s assay report, and an autoradiograph to document that the needles were loaded correctly. Nevertheless, it is still the responsibility of the institution to locally assay seeds to verify activity.

For loose seeds, the assay is straightforward. The activity of 10% of the total number of seeds or 10 seeds, whichever is larger, is measured using calibrated equipment. Loose seeds arrive nonsterile and do not require sterile technique when performing the assay. The main safety consideration during the assay is minimizing radiation exposure to personnel handling the seeds. After the assay is performed and prior to the implantation procedure, the loaded needles are sterilized.

Preloaded needles arrive sterile. Special equipment for assaying the entire needle while maintaining sterility is available, and assaying 10% of the needles is recommended. Alternately, additional nonsterile loose seeds can be ordered as part of the preloaded needle order to use for the assay. The number of loose seeds ordered for this purpose should equal either 5% of the number of seeds to be used in the implant procedure or 5 seeds, whichever is fewer.

Because the shipment of isotopes used for prostate brachytherapy usually is timed to arrive 1 or 2 days before the implant procedure, local staff has time to perform quality control procedures on the seeds and, if necessary, load the needles prior to implantation.

Quality control for permanent seed implants consists of 5 main components:

1. Verification of the seed isotope, seed manufacturer and model, patient name, and dose used to prepare the treatment plan.
2. Independent verification of the manufacturer’s seed activity.
3. Verification of correct needle loading, except for Mick applicators.
4. Verification of the patient’s identity.
5. During implantation, verification that the placement of needles, the grid location, and depth was performed as specified in the treatment plan.

**Step 5: Verification That Patient Anatomy Matches the Preplan at Implantation**

All aspects of the volume study, including patient position, equipment, Foley catheter insertion, and bladder filling should be reproduced in the operating room. The goal is to reproduce the position and shape of the prostate, urethra, and rectum at the time of the volume study. If possible, the same person should set up the patient for the volume study and in the operating room. If the anatomy does not match, the patient is repositioned and reimaged until the images adequately match the volume study. This step is essential to ensure that the seeds are implanted according to the treatment plan.

Prior to and after implantation, a radiation survey should be performed of the patient and operating room. The preimplantation survey of the patient is done to ensure that the patient does not contain radioactive material from a recent nuclear medicine study. Sometimes patients have a cardiac nuclear medicine study as part of preoperative clearance for anesthesia, and measurable radioactivity levels can be present days afterward. This quick check can prevent confusion and regulatory issues during the postimplant survey, which is required before releasing the patient.

**Step 6: Implantation**

Depending on facility protocols, permanent seed implantation is performed as a sterile or clean procedure. The type of anesthesia used also varies by facility. Once the patient is set up and anesthetized, insertion of the needles can begin. Typically, the medical physicist interprets the loading diagram produced from the treatment plan for the physician implanting the seeds. The needle template is placed against the perineum to ensure that the needles are inserted at the correct locations. The needles then are inserted into the prostate through the perineum at the locations and depths specified in the treatment plan. The correct insertion depth is verified by viewing the needle tips on TRUS images. The tips of the implant needles produce a bright signal on the ultrasound image. The use of the stepper unit for the TRUS
probe and the needle template allows accurate placement of seeds in the prostate in 3 dimensions.23 Fluoroscopic images also can be used to ensure that the needle location is correct.51

The physicist gives verbal guidance regarding the needle grid coordinates and insertion depth for each needle and records the progress of the implant procedure.32 The physician might decide to vary from the treatment plan’s needle placement, but any deviations from the treatment plan should be based on a deliberate clinical decision by the physician and recorded at the time.32,47 Having a second person monitoring the implantation and verifying that the physicist correctly provides needle placement instructions is advised. Because permanent seed implants often use more than 20 needles, and most are loaded differently, it also is essential to confirm that an inserted needle corresponds with the treatment plan. Implantation progresses quickly, and once implanted, the seeds cannot be moved or retrieved from the prostate.

After all seeds have been implanted, the urologist performs a cystoscopy to identify and remove any seeds that might have been implanted into the bladder or urethra.54 A thorough radiation survey of the operating and recovery rooms is performed to make certain no seeds were lost during the procedure. The survey should include checking trash containers, needles, the procedure table and its surroundings, along with any other equipment and areas where radioactive materials were handled.46 Survey records must be maintained along with a record of the number of seeds brought to the operating room, implanted in the patient, and returned to storage after the procedure, if any.49,55

Radiation safety activities are required to ensure safe release of the patient, and patient safety instructions must be completed as part of the procedure.53 The patient survey after implantation verifies that the patient meets the requirements for release from the medical facility.44,55 For example, one or more seeds might be flushed from the patient’s bladder when it is examined after the implantation. These seeds must be accounted for, along with all radioactive material, and disposed of as directed by the radiation safety officer based on license and regulatory requirements. Patient release instructions should include instructions to minimize exposure to family, friends, and the general public. A copy of these instructions should be provided to the patient and a copy retained.56

A discussion of the release of patients containing radioactive materials can be found in U.S. Nuclear Regulatory Commission documents.55 Although regulatory guides provide excellent recommendations on this topic, these activities are governed by federal or state regulations and license commitments.

Because all seeds must be accounted for, methods for disposal of radioactive materials should be specified in the facility’s radioactive materials license and regulations. In general, these methods include placement in decay-in-storage or return to the manufacturer for disposal. Decay-in-storage requires holding the seeds usually 10 half-lives, or almost 2 years in the case of iodine 125, before the material can be disposed of as regular trash, and only after a survey confirms that radiation levels are indistinguishable from background radiation.56 All regulations governing the shipment of radioactive materials should be observed, and only designated, trained personnel are allowed to prepare and ship packages containing radioactive materials.57

**Step 7: Postimplant Simulation**

A CT scan, an MR scan, or both can be performed to obtain a record of the implant and to allow evaluation of the treatment plan. Sometimes postimplant imaging is done on the day of implantation; it also can be done 2 to 6 weeks after the procedure. However, the timing of postimplant image acquisition should be consistent within each practice.59 The images are imported into the treatment planning system to allow calculation of the actual dose distribution from the implanted seeds.

The American Association of Physicists in Medicine (AAPM), American Brachytherapy Society, and European groups recommend the use of CT to evaluate permanent prostate seed implants.89 However, no single imaging modality is ideal for all aspects of postimplant dosimetry. Conventional radiographs alone are not used for postimplant dosimetry because neither the prostate nor critical structures can be identified accurately.99 Ultrasoundography provides prostate definition but does not clearly reveal seed positions. Using CT to evaluate the implant is current practice. According to the AAPM, “CT images of the pelvis provide excellent source definition within the limits of axial slice spacing and partial-volume artifact, and exhibit reasonable soft-tissue
systems for the prostate have automatic seed recognition software to assist with this process, but the treatment planner ultimately is responsible for seed identification. The physician, treatment planning staff, or both should contour the prostate and other anatomy used in preplanning on the postimplant images. The dose distribution then can be calculated. Evaluation techniques for the dose to the target volume can be found in the literature. At a minimum, doses for critical structures such as the urethra and rectum should be determined. Dose distribution calculation results also should be compared with the objectives of the preimplant treatment plan to determine whether the implant was satisfactory. Several references provide guidance on the best techniques for postimplant dosimetry and its reporting.

Step 8: Dose Reporting

Postplanning is performed to verify that the implant met the physician’s clinical goals and matched the written directive. The images from the postimplant simulation should be used to calculate the dose distribution that will be delivered by the implants and compare it with the planned dose distribution from the pretreatment plan. Postplanning allows identification of poorly placed implants that can be mitigated by additional treatment and, in rare cases, to identify an implant that might result in unusually severe adverse effects.

Postplanning is an essential process that helps the entire implant team improve permanent seed implantation by examining the results of the previous procedure. Continuous evaluation of the quality of implant procedures improves implantation techniques. A thorough postimplantation evaluation includes analyzing the adequacy of the pretreatment plan, the skills of the staff, and the equipment used in the procedure.

A postimplant evaluation might show that the dose distribution after the implantation does not match the originally planned dose distribution. In this case, the actual dose to the prostate and surrounding tissues from the implanted seeds must be documented. To evaluate the postimplant dose distribution, a dosimetric assessment must be performed. The actual dose distribution assessment information is essential to providing optimal patient care.

To calculate the dose distribution, each seed must be identified on the CT images. Most treatment planning systems for the prostate have automatic seed recognition software to assist with this process, but the treatment planner ultimately is responsible for seed identification. The physician, treatment planning staff, or both should contour the prostate and other anatomy used in preplanning on the postimplant images. The dose distribution then can be calculated. Evaluation techniques for the dose to the target volume can be found in the literature. At a minimum, doses for critical structures such as the urethra and rectum should be determined. Dose distribution calculation results also should be compared with the objectives of the preimplant treatment plan to determine whether the implant was satisfactory. Several references provide guidance on the best techniques for postimplant dosimetry and its reporting.

The Radiation Therapist’s Role in Prostate Implantation

With training and supervision, radiation therapists can become an integral part of the permanent prostate seed implantation team. Radiation therapists are permitted to handle radioactive seeds and complete the necessary paperwork to account for all radioactive materials used during implantation. Radiation therapists also can provide a second check for the physicists who use the loading diagram to guide the physician’s placement of the needles and seeds. The therapist can be trained to operate the TRUS unit and assist with troubleshooting any imaging issues that might arise during implantation. A therapist familiar with the paperwork for the procedure can provide second checks of the documentation of all aspects of the implantation, including radioactive material records, any variations from the treatment plan ordered by the physician during implantation, and survey records. Radiation therapists also can assist in performing the required patient and room radiation surveys, ensuring that valuable equipment is not accidentally discarded, and they can assist with cleaning and transporting equipment.

Furthermore, as a member of the implant team, the radiation therapist may:

- Schedule the patient, staff, and equipment.
- Move and set up the TRUS unit and other necessary equipment.
more severe symptoms. In 1998, a study of 117 patients who underwent permanent seed implantation showed that the IPSS peaked about 1 month postimplantation and returned to baseline in approximately 24 months. Desai et al report that “the severity of the urinary irritable symptoms developed [is] closely related to total dose to the gland. Urethral dose appears to affect frequency most significantly.”

Urinary morbidity can be ameliorated with alpha-blockers such as tamsulosin beginning 2 to 3 weeks prior to implantation and continuing until the IPSS normalizes. A prospective clinical trial of 234 patients treated either prophylactically or therapeutically with alpha-blockers also showed an IPSS peak 1 month post-implantation. Patients treated prophylactically returned to a baseline IPSS in 4 months (mean) and 3 months (median) vs those treated therapeutically, who required 10 months (mean) and 6 months (median).

Catheter dependence and the need for a postimplantation transurethral resection of the prostate or a transurethral incision of the prostate occur in less than 2% of patients. Urethral strictures occur in 4% to 12% of patients and have been correlated to overimplantation of seeds in the periapical region and the use of supplemental EBRT. Typically, urethral strictures are managed with dilatation or optical internal urethrotomy.

Rectal complications consist primarily of mild self-limited proctitis, an inflammation of the lining of the rectum. The incidence is 4% to 12% and usually resolves spontaneously. Long-term bowel function is minimally affected.

Erectile dysfunction (ED) is common after all treatments for prostate cancer. The reported rates of postimplantation ED vary widely, reflecting substantial differences in follow-up, patient selection, implantation technique, and the mode of data collection.

The mechanism of radiation-induced ED is believed to have many factors. One structure at risk could be the penile bulb. Some studies have shown that impotence following prostate brachytherapy is highly correlated with the radiation dose delivered to the penile bulb, while others have concluded the opposite. The penile bulb is an oval, hyperdense, midline structure located approximately 10 mm to 15 mm inferior to the apex of the prostate. A recent article suggested that
while the penile bulb is not a critical component of the erectile apparatus, it can be used in treatment planning as a readily identifiable surrogate for the unidentified structures responsible for ED. Fortunately, the majority of patients with brachytherapy-induced ED respond favorably to treatment with sildenafil.

**Treatment Outcomes**

Randomized clinical trials provide the best evidence to support the efficacy of a treatment. Unfortunately, the only contemporary trial in prostate cancer, a 2002 study, compared only radical prostatectomy and active surveillance. The results favored intervention for reducing prostate cancer-specific mortality and the occurrence of distant metastases. Although it might seem obvious that treating cancer leads to better patient outcomes than not treating cancer, one author summarized current trends in American medical literature as justifying doing more, while European medical literature tends to justify doing less.

Other attempted clinical trials comparing prostate cancer treatment outcomes have failed to attract sufficient numbers of patients because of strong patient preference for particular treatments and unwillingness to be randomized. Without the strong evidence of clinical trials, comparison of different treatment modalities is limited to less convincing retrospective studies.

Another difficulty in studying the outcomes of prostate cancer treatments is the indolent nature of this cancer. Because prostate cancers progress so slowly, large numbers of patients must be followed for long periods to draw valid conclusions. Changes in techniques make comparisons of current treatments difficult because the study results reflect how those treatments were performed years previously. Prostate brachytherapy, EBRT, and even surgical techniques have changed significantly, and some of today’s treatment choices did not exist years ago.

Because of its lethargic nature and the difficulty of accurately tracking the progress of prostate cancer, sequential PSA tests have become the measure of success or failure of treatments. Even though the PSA is accepted for this purpose, its relationship to disease-specific survival has not been definitively determined. Biochemical failure, or increasing PSA levels, is in some studies not correlated with increased mortality. However, it has been shown that biochemical failure is the strongest determinant of distant metastases, which are strongly related to mortality from prostate cancer but not to mortality from all causes.

In addition, there is no consensus about what constitutes biochemical failure. A literature review found that in 436 articles, 166 different definitions of biochemical failure were used. These findings show that it is difficult to compare outcomes for a single treatment at different institutions or confidently compare outcomes of a variety of treatments at different institutions. Despite this, a cross-institutional analysis showed prostate brachytherapy is at least as effective at preventing biochemical failure as EBRT or prostatectomy in low-risk, intermediate-risk, and high-risk patients.

Single-institution comparisons of treatments show similar results. A large review of outcomes for 1707 patients with T1 or T2 adenocarcinoma treated with prostate brachytherapy or prostatectomy between 1992 and 2004 showed similar results for both treatments. The authors recommended offering either treatment “without bias to all men with stage T1 or T2 organ-confined prostate cancer.” Similarly, a study of more than 1600 patients treated with permanent seed implants, EBRT, or prostatectomy between 1996 and 2001 was undertaken to identify a beneficial effect from the addition of androgen deprivation therapy, but none was seen. However, the study did show that biochemical failure rates were broadly similar for the 3 treatment modalities for both low-risk and intermediate-risk patients.

The good news for patients is that more evidence shows that permanent prostate brachytherapy produces “very favorable and durable biochemical survival” for patients in the early stages of prostate cancer. Indeed, survival rates are now so high for patients at low and intermediate risk “that only a very large, highly powered randomized trial could prove any innovation or competing modality to be superior to current permanent seed brachytherapy.”

**Conclusion**

Detailed dosimetric analyses have shown that adverse effects, complications, and quality of life outcomes after prostate brachytherapy depend on implant quality and seed placement patterns, along with the dose gradients generated. Brachytherapy treatment
planning and pre- and postoperative techniques have advanced, resulting in increased survival rates and a reduction in the incidence of ED and urinary and rectal morbidity.26

Prostate brachytherapy is an effective method for treating prostate cancer. A permanent seed implant procedure involves a complex series of steps extending over days or weeks. It is possible that well-trained radiation therapists can perform many of the tasks required for a successful procedure. The therapist has an important role and can become a valued member of the permanent seed implant team.

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References


Prostate Brachytherapy

1. Prostate cancer is responsible for approximately _____ % of cancer deaths.
   a. 10
   b. 13
   c. 20
   d. 27

2. Which statement is most correct concerning early detection and treatment of prostate cancer?
   a. Early detection of prostate cancer is of no benefit to the individual patient because treatments are ineffective.
   b. Symptoms of prostate cancer are pronounced in early-stage disease, making early detection likely and treatment more effective.
   c. Advanced prostate cancer can be treated effectively, so early detection is unnecessary.
   d. Prostate cancer typically progresses slowly and can be treated effectively.

3. The most important risk factor for prostate cancer is:
   a. ethnic group.
   b. socioeconomic status.
   c. geographical location.
   d. age.

4. Incidence of and mortality from prostate cancer vary significantly based on:
   1. socioeconomic status.
   2. geographical region.
   3. ethnicity.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

5. Which U.S. ethnic or racial group has the highest incidence and mortality rates for prostate cancer?
   a. Non-Hispanic whites
   b. African Americans
   c. Asian Americans
   d. Hispanics or Latinos

6. The principal screening methods for prostate cancer are the prostate specific antigen (PSA) test and:
   a. transrectal ultrasound (TRUS) imaging.
   b. digital rectal examination (DRE).
   c. magnetic resonance imaging.
   d. endoscopic rectal examination.

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7. The cancer detection rate is **higher** when the PSA test and DRE are used in combination than for either test alone.
   a. true 
   b. false 

8. Overdiagnosis of prostate cancer results in:
   1. unnecessary financial costs for society.
   2. unnecessary patient morbidity because of treatment.
   3. a diagnosis of prostate cancer that would never progress to symptoms or death.
   a. 1 and 2 
   b. 1 and 3 
   c. 2 and 3 
   d. 1, 2, and 3 

9. Which of the following outcomes is associated with The U.S. Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial?
   a. The trial showed no mortality benefit to prostate cancer screening.
   b. The results showed a significant reduction in mortality.
   c. The U.S. trial agreed with the results of the European Randomized Study of Screening for Prostate Cancer.
   d. One outcome was American Cancer Society recommendations that physicians discourage screening. 

10. In 2012, the U.S. Preventative Services Task Force recommended against PSA screening for prostate cancer for men:
    a. of any age.
    b. younger than 25 years of age.
    c. aged 25 to 30 years.
    d. aged 30 to 40 years. 

11. Introduction of a new cancer screening technology would be expected to:
    a. increase mortality over time and decrease incidence immediately.
    b. increase incidence immediately and decrease mortality over time.
    c. have no effect on incidence immediately and increase mortality immediately.
    d. increase incidence immediately and have no effect on mortality over time. 

12. If a PSA test and a DRE indicate that a patient might have prostate cancer, what procedure is typically performed?
    a. transrectal ultrasonography 
    b. core-needle biopsy 
    c. lymph node dissection 
    d. nomogram 

13. In some cases, a biopsy might reveal ______ cells, a possible precursor to prostate cancer.
    a. acinar epithelial 
    b. prostatic intraepithelial neoplasia 
    c. urothelial transitional 
    d. prostatic sarcoid neoplastic 

14. A Gleason score of 6 or less correlates to:
    a. no malignancy found. 
    b. a low-grade cancer that is mildly aggressive. 
    c. a medium-grade cancer that is moderately aggressive. 
    d. a high-grade cancer that is highly aggressive.
15. After prostate cancer is diagnosed, which of the following tests can be used to determine the stage of prostate cancer?
   1. bone scan
   2. pelvic lymphadenectomy
   3. seminal vesicle biopsy
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

16. The most commonly used brachytherapy treatment for prostate cancer is permanent implantation of low-activity radioactive seeds.
   a. true
   b. false

17. Which isotope is not used for prostate brachytherapy?
   a. iridium 192
   b. iodine 125
   c. cesium 131
   d. palladium 103

18. Intraoperative treatment planning combines which of the following procedures?
   1. volume study
   2. seed implantation
   3. core-needle biopsy
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

19. According to the article, the use of stranded seeds can reduce which of the following?
   a. seed degeneration
   b. seed migration
   c. edema
   d. bleeding

20. Preloaded needles are:
   1. always loaded on site.
   2. sometimes loaded using loose spacers or stranded seeds.
   3. available from special nuclear pharmacies.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

21. Which of the following is not an approach to prostate brachytherapy treatment planning as defined by the American Brachytherapy Society?
   a. preplanning
   b. intraoperative planning
   c. inverse dose calculation
   d. dynamic dose calculation

22. According to the article, the volume study should be performed no earlier than ______ week(s) prior to implantation.
   a. 1
   b. 2 to 3
   c. 4 to 6
   d. 6 to 8

23. TRUS images collected during the volume study primarily are used to:
   1. evaluate prostate size.
   2. evaluate prostate location relative to the pubic arch.
   3. prepare the treatment plan.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

continued on next page
24. What causes differences in prostate volume, shape, and position between the volume study and the operating room?
   1. imaging technique
   2. equipment
   3. patient positioning
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

25. Quality control for prostate implants does not include verification:
   a. of correct needle loading for Mick applicators.
   b. of the manufacturer’s seed activity.
   c. of the patient’s identity.
   d. that the needle placement matched what was specified in the treatment plan.

26. Which of the following is true regarding postimplant radiation surveys?
   a. The survey must be performed to ensure that no seeds were lost during the procedure.
   b. Postimplant radiation surveys do not include checking that the patient received the correct number of seeds.
   c. They require that only the operating room is surveyed to locate lost seeds.
   d. These are not required if waived by the facility’s radiation safety officer.

27. For postimplant simulation, which of the following is recommended by the American Brachytherapy Society?
   a. TRUS imaging
   b. computed tomography imaging
   c. computed tomography and magnetic resonance image fusion imaging
   d. magnetic resonance imaging alone

28. Which of the following is true regarding calculating dose distribution?
   a. It is of no benefit to patients.
   b. The calculation is only of value for physician learning.
   c. Dose distribution calculation uses only TRUS imaging to identify seed locations.
   d. This calculation is performed by identifying seed location with computed tomography imaging.

29. Rectal morbidity greatly affects long-term bowel function and commonly is a serious issue after prostate brachytherapy.
   a. true
   b. false

30. Which of the following applies to biochemical failure?
   1. It is the result of decreasing PSA levels over time.
   2. It is defined differently in different studies.
   3. It is the strongest determinant of distant metastases.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3