

**American College of Radiology
ACR Appropriateness Criteria®**

Clinical Condition: Post-treatment Follow-up of Prostate Cancer

Variant 1: Status post radical prostatectomy. Rising PSA level.

| Radiologic Procedure | Rating | Comments | RRL* |
|--|--------|--|----------------------------------|
| Tc-99m bone scan whole body | 8 | More likely to be helpful if PSA >10. Readily available. Scan to include correlative radiographs. If bone scan is positive, no further imaging workup is necessary. | Med |
| CT abdomen and pelvis with contrast | 7 | For nodal involvement. Not very useful for local recurrence. | High |
| US-guided biopsy prostate bed transrectal | 6 | Should be done under US guidance to confirm recurrence. Local recurrent tumor may be visualized on transrectal US in only 30% to 50% of cases. | None |
| MRI pelvis with or without contrast | 6 | Endorectal coil MRI may be useful for evaluating local extension or pelvic nodal involvement. Use of Gadolinium injection is promising in detecting local recurrence. MRI-guided biopsy is not widely available. If bone scan is inconclusive, MRI would be helpful for further characterization. See statement regarding contrast in text under "Anticipated Exceptions." | None |
| US pelvis (prostate) transrectal | 4 | Will not show microscopic occurrences. | None |
| ProstaScint scan | 3 | May be more appropriate if decisions regarding local therapy are being considered. Fusion imaging with CT or MRI has been reported. | High |
| FDG-PET whole body | 3 | PET/CT promising, but data insufficient to warrant routine use. | High |
| US pelvis (prostate) transabdominal | 2 | | None |
| X-ray radiographic survey whole body | 1 | | Med |
| X-ray intravenous urography | 1 | If bone scan shows obstruction or elevated creatinine. | Med |
| Rating Scale: 1=Least appropriate, 9=Most appropriate | | | *Relative Radiation Level |

Clinical Condition:**Post-treatment Follow-up of Prostate Cancer****Variant 2:****Status post radiation therapy. Rising PSA level.**

| Radiologic Procedure | Rating | Comments | <u>RRL*</u> |
|--|---------------|--|----------------------------------|
| Tc-99m bone scan whole body | 8 | Scan to include correlative radiographs. | Med |
| CT abdomen and pelvis with contrast | 7 | | High |
| US-guided biopsy prostate bed transrectal | 6 | | None |
| MRI pelvis with or without contrast | 6 | Use of Gadolinium injection is promising in detecting local recurrence. See statement regarding contrast in text under "Anticipated Exceptions." | None |
| US pelvis (prostate) transrectal | 3 | | None |
| ProstaScint scan | 3 | | High |
| FDG-PET whole body | 3 | | High |
| US pelvis (prostate) transabdominal | 1 | | None |
| X-ray radiographic survey whole body | 1 | | Med |
| X-ray intravenous urography | 1 | | Med |
| Rating Scale: 1=Least appropriate, 9=Most appropriate | | | *Relative Radiation Level |

Variant 3:**Treatment of metastatic prostate cancer by androgen deprivation therapy (ADT).
Rising PSA level.**

| Radiologic Procedure | Rating | Comments | <u>RRL*</u> |
|--|---------------|--|----------------------------------|
| Tc-99m bone scan whole body | 8 | Obtain radiographs as needed. | Med |
| CT abdomen and pelvis with contrast | 7 | | High |
| MRI pelvis with or without contrast | 6 | See statement regarding contrast in text under "Anticipated Exceptions." | None |
| ProstaScint scan | 2 | | High |
| FDG-PET whole body | 2 | | High |
| US pelvis (prostate) transrectal | 1 | | None |
| US-guided biopsy prostate bed transrectal | 1 | | None |
| X-ray intravenous urography | 1 | May be indicated if bone scan shows obstruction or elevated creatinine. | Med |
| US pelvis (prostate) transabdominal | 1 | | None |
| X-ray radiographic survey whole body | 1 | | Med |
| Rating Scale: 1=Least appropriate, 9=Most appropriate | | | *Relative Radiation Level |

POST-TREATMENT FOLLOW-UP OF PROSTATE CANCER

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Summary of Literature Review

In evaluating of patients with recurrent or metastatic prostate cancer, it is important to define the location, size and the extent of local and/or distant tumors. Prostate cancer is treated by four standard methods: radical prostatectomy, radiation therapy, cryosurgical ablation, or androgen deprivation therapy (ADT). The treatment choice is based on the stage of the tumor as well as the histology and grade and is influenced to a certain extent by the preference of the treating physician and the patient. After treatment, patients are followed at periodic intervals with measurement of serum prostate-specific antigen (PSA) levels and digital rectal examination (DRE). However, DRE is frequently unreliable in evaluating local recurrent disease after radical prostatectomy [1].

PSA is produced by the epithelial cells of the prostate gland and is therefore specific for prostatic tissue. A rise in PSA is detected in the serum when the prostate gland has been disrupted as with prostate cancer, benign prostatic hyperplasia (BPH), or acute prostatitis, or following prostate biopsy. PSA is now widely used as a tumor marker for prostate cancer, both for detection and for monitoring response to therapy. No imaging study is necessary after treatment for clinically localized prostate cancer unless the PSA is elevated, the DRE is abnormal, or the patient has bone pain [1].

Although PSA alone does not differentiate local from distant disease recurrence, the patterns of PSA rise after local therapy can help to differentiate local from distant failure. Patients with a late biochemical recurrence (>24

months after local treatment), low PSA velocity (change in PSA over time), and/or prolonged PSA doubling time (>6 months) most likely have recurrent local disease [2]. Conversely, patients with a rapid PSA recurrence (<24 months after local treatment), high PSA velocity, or short PSA doubling time (<6 months) are more likely to have distant disease recurrence [2].

Bone x-rays are not sensitive for detecting metastasis compared with radionuclide bone scans, but they may be helpful in identifying degenerative changes as the cause for a positive bone scan [3,4]. Chest x-ray is not necessary because lung metastases are only found in late-stage disease after other more common sites are involved by tumor [5].

Whole-body bone scans are frequently performed for detecting skeletal metastases in patients with rising PSA following treatment. If the bone scan is positive for metastatic disease, no other imaging is indicated. Pollen et al [6] have suggested that bone scans be done annually in patients without evidence of metastatic disease and in patients with clinical or biochemical indications of recurrent disease. However, since bone scans are rarely positive without symptoms or without abnormal PSA levels, the routine use of this study post treatment is considered unproductive by some investigators [7-10]. Sissons et al [11] found three patients with bone metastases in a series of 59 patients without suspicious serum PSA levels. A bone scan may be inconclusive since it is a sensitive but not specific examination. Magnetic resonance imaging (MRI) may be helpful in the diagnosis of bone metastasis when other examinations are conflicting, and it can be used to determine response to hormonal treatment [12]. A comparison of MRI and bone scans showed 818 abnormal vertebrae detected by MRI versus 499 by bone scan in the same group of patients [13].

Post Radical Prostatectomy

Following radical prostatectomy, PSA levels are expected to be undetectable to less than 0.15 ng/ml within several weeks of surgery. Waiting 6-8 weeks after treatment is advisable before assessing the serum PSA value since the half-life of serum PSA is relatively long. Since the PSA is specific for the prostate, detectable PSA levels mean that there is residual prostate tissue. If there is a rise in a previously undetectable or stable postoperative PSA level, a prompt search for persistent, recurrent, or metastatic disease should be pursued. The major objective of the diagnostic imaging studies is to assess patients for the presence of distant metastatic disease or local recurrent disease, each requiring different forms of systemic or local therapy.

Radionuclide Bone Scintigraphy

Radionuclide bone scan is traditionally the first examination obtained. If the bone scan is positive for metastatic disease, no further imaging studies are necessary. If the bone scan is inconclusive, further

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imaging studies are performed, including conventional radiographs, MRI, or computed tomography (CT). However, the level of post-treatment PSA that should prompt a bone scan is uncertain. In a study of patients with biochemical failure following radical prostatectomy, the probability of a positive bone scan was less than 5% with PSA levels between 40-45 ng/ml. In another study, bone scan was limited until PSA rose above 30-40 ng/ml [14]. Men with PSA doubling times less than 6 months after radical prostatectomy were at increased risk of a positive bone scan (26% vs 3%) or positive CT (24% vs 0%) compared to those with longer PSA doubling time [15].

Based on a survey by the American Urology Association (AUA) on current practice strategies for follow-up after radical prostatectomy, bone scans are recommended only if the patient had symptoms of bone pain, a rapid rise in PSA (PSA velocity), or a significantly elevated PSA value [16].

Transrectal Ultrasonography

The use of imaging in the evaluation of local tumor recurrence is controversial. Transrectal ultrasound (TRUS) with guided biopsy of the vesicourethral anastomosis (VUA) has been the standard imaging approach to document local recurrence [17,18]. A palpable abnormality is not always a good guide to the location of recurrent or progressive tumor because postoperative fibrosis may mimic tumor [19]. Negative results of US-guided transrectal biopsy of the VUA, regardless of a palpable mass or indurations, may be inconclusive because of sampling error. The use of biopsy has been questioned in the face of a rising PSA level, since the negative results are unreliable and elevated PSA levels usually precede clinical evidence of local recurrence by one or more years. Repeat TRUS with VUA needle biopsy may be necessary in one-third of cases [20,21]. The yield for detecting local recurrent tumor with TRUS with needle biopsy rises significantly with serum PSA levels [20,22,23]. Only about 25% of men with prostatectomy PSA levels of less than 1 ng/ml have histologic confirmation of local recurrence after biopsy of the prostatic fossa [20]. None of the patients with PSA levels of 0.5 ng/ml or less who had negative DRE and TRUS have a biopsy-proved local recurrence [24].

A staging pelvic lymphadenectomy is sometimes done at the time of a radical retropubic prostatectomy; therefore, follow-up of the lymph nodes usually is not necessary in such cases. However, if the biopsy of the VUA is repeatedly negative in the face of a rising PSA level, then pelvic imaging looking for adenopathy with CT or MRI may be indicated [25].

Computed Tomography

CT is not effective for detecting recurrent tumor in the surgical bed [26]. A CT scan can recognize only local recurrences that are greater than or equal to 2 grams [27]. The mean PSA value associated with a positive CT scan after radical prostatectomy was 27.4 ng/ml [16].

In the evaluation of nodal disease, CT has replaced lymphography and relies on nodal size to detect nodal metastases. Using 1 cm as a cutoff, studies have reported sensitivity between 27%-75% and specificity between 66%-100%. By decreasing the size cutoff to 0.7 cm and by sampling suspicious nodes by fine-needle aspiration (FNA), Oyen et al [28] were able to attain a sensitivity of 78% and specificity of 100%. However, this decreased size criteria with concomitant use of FNA has not been widely adopted [29]. CT is useful in detecting bone and visceral metastases, although bone scan and MRI are superior in the diagnosis and follow-up of bone metastases [29].

Magnetic Resonance Imaging

The use of MRI is evolving and has potential to evaluate both local recurrence and distant bony and nodal metastases. MRI utilizing an endorectal coil is used to evaluate local recurrence [25,29-31]. In a study by Silverman et al, MRI was positive in men with cancer recurrence only with a concomitant rise in PSA level [31]. In the absence of PSA rise, despite suspicious findings on DRE, the MRI was negative. In another study of 16 patients with rising PSA after radical prostatectomy and negative transrectal US-guided biopsy by Takeda et al [32], gadolinium-enhanced, dynamic endorectal coil MRI demonstrated nodular enhancing lesions in 13 of 16 patients (84%). In 8 of the 13 patients with positive MRI findings, PSA levels decreased after radiation therapy. Concurrent MRI-directed biopsy of suspicious sites is not available, making histologic correlation and assessment of its true utility difficult.

The accuracy of MRI for staging pelvic lymph nodes by size criteria is similar to that of CT. MRI can be more sensitive and specific in the diagnosis of bone metastases with better spatial and contrast resolution when compared to bone scan [33]. MRI cannot cover the entire skeleton within a reasonable time at a reasonable cost. Therefore, it is only useful when other imaging modality findings are indeterminate. Response of bone metastases to treatment can be more accurately monitored by serial MRI scans [12].

Post Radiation Therapy

Prostate cancer treated with radiation therapy (RT) is monitored differently, since the prostate and the lymph nodes are left in place. Following radiation therapy, the serum PSA level decreases in the majority of the patients during the first year. Surveillance for tumor recurrence in patients post radiation therapy should include a DRE and serial serum PSA levels. The prostate gland becomes atrophic and fibrotic after radiation treatment, making distinction between local recurrent disease and benign irradiated prostatic gland difficult by DRE alone [25]. The American Society of Therapeutic Radiology and Oncology (ASTRO) has defined recurrence following radiation therapy as three consecutive rises in serum PSA following a post-RT PSA nadir [34]. An increasing serum PSA level will prompt radionuclide bone scan. If the bone scan is positive, no further evaluation is necessary. If the bone scan is inconclusive, MRI may be helpful. If the

bone scan is negative or inconclusive, TRUS-directed biopsy of the prostate is indicated. MRI may be indicated to depict local recurrence after radiotherapy. In 22 patients with rising PSA after external beam radiation therapy, contrast-enhanced dynamic MRI demonstrated areas of recurrent intraprostatic tumor more accurately and with less interobserver variability than T2-weighted images did [35]. Evaluation for lymph node enlargement is done by either CT or MRI. Both imaging tests are relatively accurate for detecting lymph node enlargement [36,37].

Post Cryosurgery

Serum PSA should fall to a low level 6 to 8 weeks following cryosurgery and should not rise on successive occasions. Follow-up after cryosurgery should be the same as that after radiotherapy, and it seems reasonable to use similar guidelines to define disease recurrence [38]. It is often difficult to differentiate recurrent tumor from post-cryosurgery changes by means of DRE, TRUS, and MRI.

Post Androgen Deprivation Therapy

ADT — using bilateral orchiectomy, luteinizing hormone-releasing hormone analogue, diethylstilbestrol, bilateral orchiectomy and flutamide, and luteinizing hormone-releasing hormone analogue and flutamide — may control prostate cancer for long periods by decreasing the size of the tumor, thus relieving pain and other symptoms in patients with advanced disease. ADT may be added to definitive therapy (radical prostatectomy, radiation therapy, and cryosurgery) in patients with early-stage disease as adjuvant therapy (after definitive therapy) or neoadjuvant therapy (prior to definitive therapy). ADT may have a direct suppressive effect on serum PSA level that is independent of tumor activity. PSA production is under hormonal control, and ADT reduces the cell's ability to produce and secrete PSA. Therefore, serum PSA is not always a reliable marker of disease status in these patients.

In a study by Ruckle et al [39] serial serum PSA measurements after ADT were able to predict response to the treatment. Patients whose serum PSA levels remained elevated for more than three months after treatment had a high risk of disease progression within two years. Serial PSA determinations in combination with radionuclide bone scanning are clinically warranted in these patients with advanced disease as follow-up. In patients with an increasing serum PSA level, the investigation can end if the bone scan is conclusive. CT is also useful in assessing nodal or visceral metastatic disease. If the bone scan and CT are negative or inconclusive, further investigation for metastasis may be pursued using MRI.

Summary

All patients treated for prostate cancer are monitored with serial PSA measurements and DRE. A radionuclide bone scan has traditionally been obtained at one year after treatment regardless of PSA level. This tradition is now being challenged, but bone scans are still commonly obtained after ADT.

A rising PSA level usually prompts a bone scan. If it is positive, no other imaging is indicated. An equivocal bone scan may lead to more refined imaging such as MRI or CT. A negative bone scan requires further investigation such as TRUS-guided biopsy (post local therapy, including prostatectomy, radiation therapy, and cryosurgery) and lymph node evaluation with CT or MRI. Endorectal coil MRI is evolving and provides useful information regarding local recurrence as well as pelvic nodal and bone metastases. Chest x-ray is not necessary because prostatic lung metastasis is only found in late stage disease after other metastatic sites are well established. Bone x-rays are only used to help in identifying degenerative bone changes as a cause for abnormal foci on radionuclide bone scans.

New Techniques

ProstaScint Scan (111 Indium capromab pendetide)

ProstaScint is a murine monoclonal antibody that targets prostate-specific membrane antigen (PSMA). ProstaScint imaging in the detection of metastases and local recurrence has been reported to have a sensitivity of 49%-94%, a specificity of 65%-72%, and an overall accuracy of 63%-80%. However, there are still questions remaining regarding its optimal use. Further, the scans are challenging to interpret and expensive to perform. It has been reported that the likelihood of a positive scan outcome is enhanced when patients with high PSA levels and high Gleason grade tumors are felt to have a recurrence [40-43]. Fused SPECT/CT or MRI will improve the specificity of ProstaScint examination in detecting recurrent prostate cancer [44,45].

Positron Emission Tomography with 2-deoxy-2- [F-18] fluoro-D-glucose

Many foci of metastatic prostate cancer demonstrate increased FDG accumulation, though this uptake is generally low compared to the other cancers. FDG-PET is relatively insensitive in detecting osseous metastases compared to standard bone scintigraphy [46]. Helical CT and FDG-PET scanning may be more helpful than ProstaScint imaging in detecting nodal disease in men with high PSA level after radical prostatectomy [47]. PET/CT can provide information about anatomy and metabolism of the recurrent and metastatic disease.

Positron Emission Tomography with Newer Radiotracers including [11-C]-acetate, [11-C or 18-F]-choline, and [11-C]-methionine

PET with 11C acetate [48] and PET with 11C and 18F choline have been reported to detect recurrent disease in patients with high PSA after local treatment [49,50]. PET with 11C methionine has been reported to be more sensitive than FDG-PET in detecting bone metastases [51]. The efficacy and clinical utility of PET with these new agents are under investigation.

Magnetic Resonance Spectroscopic Imaging

MR spectroscopic imaging (MRSI) provides metabolic information from 3-dimensional multiple contiguous volumes (voxels) within the prostate gland [52]. Addition of the metabolic information provided by MRSI to the

morphologic information provided by endorectal coil MRI can help discriminate regions of residual tumor from other prostatic tissues and necrosis following radiation therapy [53,54], cryosurgery [55], and hormone therapy. Time-dependent effects of hormone therapy on prostate metabolism are detected on MRSI. However, prostate metabolic profiles associated with prostate cancer can be identifiable on MRSI in patients with PSA levels exceeding 0.20 ng/ml and with 3 months or less of neoadjuvant hormone therapy for locally confined prostate cancer [56].

Newer lymph nodal Magnetic Resonance Contrast Agent MRI following IV administration of lymphotropic superparamagnetic iron oxide nanoparticles has been reported to improve detection of positive lymph nodal metastases from prostate cancer when compared to unenhanced MRI [57]. This MRI contrast agent is investigational and is not commercially available at this time.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, <30 mL/min/1.73m²), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m². For more information, please see the [ACR Manual on Contrast Media](#) [58].

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document.

| Relative Radiation Level Designations | |
|---------------------------------------|-------------------------------|
| Relative Radiation Level | Effective Dose Estimate Range |
| None | 0 |
| Minimal | < 0.1 mSv |
| Low | 0.1-1 mSv |
| Medium | 1-10 mSv |
| High | 10-100 mSv |

Supporting Document(s)

- [ACR Appropriateness Criteria® Overview](#)
- Evidence table under review

References

1. Pound CR, Christens-Barry OW, Gurganus RT, Partin AW, Walsh PC. Digital rectal examination and imaging studies are unnecessary in men with undetectable prostate specific antigen following radical prostatectomy. *J Urol* 1999; 162(4):1337-1340.
2. Partin AW, Pearson JD, Landis PK, et al. Evaluation of serum prostate-specific antigen velocity after radical prostatectomy to distinguish local recurrence from distant metastases. *Urology* 1994; 43(5):649-659.
3. Levenson RM, Sauerbrunn BJ, Bates HR, Newman RD, Eddy JL, Ihde DC. Comparative value of bone scintigraphy and radiography in monitoring tumor response in systemically treated prostatic carcinoma. *Radiology* 1983; 146(2):513-518.
4. Osmond JD, 3rd, Pendergrass HP, Potsaid MS. Accuracy of 99mTC-diphosphonate bone scans and roentgenograms in the detection of prostate, breast and lung carcinoma metastases. *Am J Roentgenol Radium Ther Nucl Med* 1975; 125(4):972-977.
5. Bumpus HC, Jr. Carcinoma of the prostate. *Surg Gynecol Obstet* 1926; 43:150-155.
6. Pollen JJ, Gerber K, Ashburn WL, Schmidt JD. The value of nuclear bone imaging in advanced prostatic cancer. *J Urol* 1981; 125(2):222-223.
7. Freitas JE, Gilvydas R, Ferry JD, Gonzalez JA. The clinical utility of prostate-specific antigen and bone scintigraphy in prostate cancer follow-up. *J Nucl Med* 1991; 32(7):1387-1390.
8. Huben RP, Schellhammer PF. The role of routine followup bone scans after definitive therapy of localized prostatic cancer. *J Urol* 1982; 128(3):510-512.
9. Miller PD, Eardley I, Kirby RS. Prostate specific antigen and bone scan correlation in the staging and monitoring of patients with prostatic cancer. *Br J Urol* 1992; 70(3):295-298.
10. Terris MK, Klonecke AS, McDougall IR, Stamey TA. Utilization of bone scans in conjunction with prostate-specific antigen levels in the surveillance for recurrence of adenocarcinoma after radical prostatectomy. *J Nucl Med* 1991; 32(9):1713-1717.
11. Sissons GR, Clements R, Peeling WB, Penney MD. Can serum prostate-specific antigen replace bone scintigraphy in the follow-up of metastatic prostatic cancer? *Br J Radiol* 1992; 65(778):861-864.
12. Turner JW, Hawes DR, Williams RD. Magnetic resonance imaging for detection of prostate cancer metastatic to bone. *J Urol* 1993; 149(6):1482-1484.
13. Algra PR, Bloem JL, Tissing H, Falke TH, Arndt JW, Verboom LJ. Detection of vertebral metastases: comparison between MR imaging and bone scintigraphy. *Radiographics* 1991; 11(2):219-232.
14. Cher ML, Bianco FJ, Jr., Lam JS, et al. Limited role of radionuclide bone scintigraphy in patients with prostate specific antigen elevations after radical prostatectomy. *J Urol* 1998; 160(4):1387-1391.
15. Okotie OT, Aronson WJ, Wieder JA, et al. Predictors of metastatic disease in men with biochemical failure following radical prostatectomy. *J Urol* 2004; 171(6 Pt 1):2260-2264.
16. Kane CJ, Amling CL, Johnstone PA, et al. Limited value of bone scintigraphy and computed tomography in assessing biochemical failure after radical prostatectomy. *Urology* 2003; 61(3):607-611.
17. Salomon CG, Flisak ME, Olson MC, Dudiak CM, Flanigan RC, Waters WB. Radical prostatectomy: transrectal sonographic

- evaluation to assess for local recurrence. *Radiology* 1993; 189(3):713-719.
18. Wasserman NF, Kapoor DA, Hildebrandt WC, et al. Transrectal US in evaluation of patients after radical prostatectomy. Part II. Transrectal US and biopsy findings in the presence of residual and early recurrent prostatic cancer. *Radiology* 1992; 185(2):367-372.
 19. Lightner DJ, Lange PH, Reddy PK, Moore L. Prostate specific antigen and local recurrence after radical prostatectomy. *J Urol* 1990; 144(4):921-926.
 20. Connolly JA, Shinohara K, Presti JC, Jr., Carroll PR. Local recurrence after radical prostatectomy: characteristics in size, location, and relationship to prostate-specific antigen and surgical margins. *Urology* 1996; 47(2):225-231.
 21. Foster LS, Jajodia P, Fournier G, Jr., Shinohara K, Carroll P, Narayan P. The value of prostate specific antigen and transrectal ultrasound guided biopsy in detecting prostatic fossa recurrences following radical prostatectomy. *J Urol* 1993; 149(5):1024-1028.
 22. Leventis AK, Shariat SF, Slawin KM. Local recurrence after radical prostatectomy: correlation of US features with prostatic fossa biopsy findings. *Radiology* 2001; 219(2):432-439.
 23. Shekarriz B, Upadhyay J, Wood DP, Jr., et al. Vesicourethral anastomosis biopsy after radical prostatectomy: predictive value of prostate-specific antigen and pathologic stage. *Urology* 1999; 54(6):1044-1048.
 24. Naya Y, Okihara K, Evans RB, Babaian RJ. Efficacy of prostatic fossa biopsy in detecting local recurrence after radical prostatectomy. *Urology* 2005; 66(2):350-355.
 25. Nudell DM, Wefer AE, Hricak H, Carroll PR. Imaging for recurrent prostate cancer. *Radiol Clin North Am* 2000; 38(1):213-229.
 26. Older RA, Lippert MC, Gay SB, Omary RA, Hillman BJ. Computed tomography appearance of the prostatic fossa following radical prostatectomy. *Acad Radiol* 1995; 2(6):470-474.
 27. Kramer S, Gorich J, Gottfried HW, et al. Sensitivity of computed tomography in detecting local recurrence of prostatic carcinoma following radical prostatectomy. *Br J Radiol* 1997; 70(838):995-999.
 28. Oyen RH, Van Poppel HP, Ameye FE, Van de Voorde WA, Baert AL, Baert LV. Lymph node staging of localized prostatic carcinoma with CT and CT-guided fine-needle aspiration biopsy: prospective study of 285 patients. *Radiology* 1994; 190(2):315-322.
 29. Hricak H, Schoder H, Pucar D, et al. Advances in imaging in the postoperative patient with a rising prostate-specific antigen level. *Semin Oncol* 2003; 30(5):616-634.
 30. Sella T, Schwartz LH, Swindle PW, et al. Suspected local recurrence after radical prostatectomy: endorectal coil MR imaging. *Radiology* 2004; 231(2):379-385.
 31. Silverman JM, Krebs TL. MR imaging evaluation with a transrectal surface coil of local recurrence of prostatic cancer in men who have undergone radical prostatectomy. *AJR* 1997; 168(2):379-385.
 32. Takeda M, Akiba H, et al. Value of multi-sectional fast dynamic contrast enhanced MR imaging in patients with elevated PSA levels after radical prostatectomy. *AJR* 2002; 178(suppl):97.
 33. Taoka T, Mayr NA, Lee HJ, et al. Factors influencing visualization of vertebral metastases on MR imaging versus bone scintigraphy. *AJR* 2001; 176(6):1525-1530.
 34. Horwitz EM, Vicini FA, Ziaja EL, Dmuchowski CF, Stromberg JS, Martinez AA. The correlation between the ASTRO Consensus Panel definition of biochemical failure and clinical outcome for patients with prostate cancer treated with external beam irradiation. American Society of Therapeutic Radiology and Oncology. *Int J Radiat Oncol Biol Phys* 1998; 41(2):267-272.
 35. Rouviere O, Valette O, Grivolat S, et al. Recurrent prostate cancer after external beam radiotherapy: value of contrast-enhanced dynamic MRI in localizing intraprostatic tumor--correlation with biopsy findings. *Urology* 2004; 63(5):922-927.
 36. Castellino RA. Retroperitoneal and pelvic lymph node imaging. *Cancer* 1991; 67(4 Suppl):1219-1222.
 37. Hricak H, Dooms GC, Jeffrey RB, et al. Prostatic carcinoma: staging by clinical assessment, CT, and MR imaging. *Radiology* 1987; 162(2):331-336.
 38. Ornstein DK, Oh J, Herschman JD, Andriole GL. Evaluation and management of the man who has failed primary curative therapy for prostate cancer. *Urol Clin North Am* 1998; 25(4):591-601.
 39. Ruckle HC, Klee GG, Oesterling JE. Prostate-specific antigen: concepts for staging prostate cancer and monitoring response to therapy. *Mayo Clin Proc* 1994; 69(1):69-79.
 40. Elgamal AA, Troychak MJ, Murphy GP. ProstaScint scan may enhance identification of prostate cancer recurrences after prostatectomy, radiation, or hormone therapy: analysis of 136 scans of 100 patients. *Prostate* 1998; 37(4):261-269.
 41. Kahn D, Williams RD, Manyak MJ, et al. 111Indium-capromab pentetide in the evaluation of patients with residual or recurrent prostate cancer after radical prostatectomy. The ProstaScint Study Group. *J Urol* 1998; 159(6):2041-2046; discussion 2046-2047.
 42. Petronis JD, Regan F, Lin K. Indium-111 capromab pentetide (ProstaScint) imaging to detect recurrent and metastatic prostate cancer. *Clin Nucl Med* 1998; 23(10):672-677.
 43. Wilkinson S, Chodak G. The role of 111indium-capromab pentetide imaging for assessing biochemical failure after radical prostatectomy. *J Urol* 2004; 172(1):133-136.
 44. Schettino CJ, Kramer EL, Noz ME, Taneja S, Padmanabhan P, Lepor H. Impact of fusion of indium-111 capromab pentetide volume data sets with those from MRI or CT in patients with recurrent prostate cancer. *AJR* 2004; 183(2):519-524.
 45. Sodee DB, Ellis RJ, Samuels MA, et al. Prostate cancer and prostate bed SPECT imaging with ProstaScint: semiquantitative correlation with prostatic biopsy results. *Prostate* 1998; 37(3):140-148.
 46. Shreve PD, Grossman HB, Gross MD, Wahl RL. Metastatic prostate cancer: initial findings of PET with 2-deoxy-2-[F-18]fluoro-D-glucose. *Radiology* 1996; 199(3):751-756.
 47. Seltzer MA, Barbaric Z, Belldgrun A, et al. Comparison of helical computerized tomography, positron emission tomography and monoclonal antibody scans for evaluation of lymph node metastases in patients with prostate specific antigen relapse after treatment for localized prostate cancer. *J Urol* 1999; 162(4):1322-1328.
 48. Oyama N, Miller TR, Dehdashti F, et al. 11C-acetate PET imaging of prostate cancer: detection of recurrent disease at PSA relapse. *J Nucl Med* 2003; 44(4):549-555.
 49. Cimitan M, Bortolus R, Morassut S, et al. [(18)F]fluorocholine PET/CT imaging for the detection of recurrent prostate cancer at PSA relapse: experience in 100 consecutive patients. *Eur J Nucl Med Mol Imaging* 2006; 33(12):1387-1398.
 50. de Jong IJ, Pruim J, Elsinga PH, Vaalburg W, Mensink HJ. 11C-choline positron emission tomography for the evaluation after treatment of localized prostate cancer. *Eur Urol* 2003; 44(1):32-38; discussion 38-39.
 51. Nunez R, Macapinlac HA, Yeung HW, et al. Combined 18F-FDG and 11C-methionine PET scans in patients with newly progressive metastatic prostate cancer. *J Nucl Med* 2002; 43(1):46-55.
 52. Kurhanewicz J, Vigneron DB, Hricak H, et al. Prostate cancer: metabolic response to cryosurgery as detected with 3D H-1 MR spectroscopic imaging. *Radiology* 1996; 200(2):489-496.
 53. Coakley FV, Teh HS, Qayyum A, et al. Endorectal MR imaging and MR spectroscopic imaging for locally recurrent prostate cancer after external beam radiation therapy: preliminary experience. *Radiology* 2004; 233(2):441-448.
 54. Pucar D, Shukla-Dave A, Hricak H, et al. Prostate cancer: correlation of MR imaging and MR spectroscopy with pathologic findings after radiation therapy-initial experience. *Radiology* 2005; 236(2):545-553.
 55. Parivar F, Hricak H, Shinohara K, et al. Detection of locally recurrent prostate cancer after cryosurgery: evaluation by transrectal ultrasound, magnetic resonance imaging, and three-dimensional proton magnetic resonance spectroscopy. *Urology* 1996; 48(4):594-599.
 56. Mueller-Lisse UG, Swanson MG, Vigneron DB, Kurhanewicz J. Magnetic resonance spectroscopy in patients with locally confined prostate cancer: association of prostatic citrate and metabolic atrophy with time on hormone deprivation therapy, PSA level, and biopsy Gleason score. *Eur Radiol* 2007; 17(2):371-378.
 57. Harisinghani MG, Barentsz J, Hahn PF, et al. Noninvasive detection of clinically occult lymph-node metastases in prostate cancer. *N Engl J Med* 2003; 348(25):2491-2499.
 58. American College of Radiology. *Manual on Contrast Media*. Available at: http://www.acr.org/SecondaryMainMenuCategories/quality_safety/contrast_manual.aspx.

The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.