American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Follow-up of Renal Cell Carcinoma**

Variant 1: **Asymptomatic patient; no known metastases.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	8	Not necessary if CT chest performed.	Min
CT abdomen and pelvis with contrast	8	Particularly if primary was high stage and/or high grade.	High
MRI abdomen and pelvis without and with contrast	6	See comments regarding contrast in text under "Anticipated Exceptions."	None
CT chest with or without contrast	6		Med
FDG-PET whole body	4	May have a role when CT and/or bone scan findings are equivocal.	High
US kidney retroperitoneal	3		None
X-ray intravenous urography	2		Med
NUC Tc-99m bone scan whole body	2		Med
MRI head without and with contrast	1		None
X-ray abdomen	1		Med
CT head without and with contrast	1		Med
X-ray radiographic survey whole body	1		Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Expert Panel on Urologic Imaging: David D. Casalino, MD[1]; Isaac R. Francis, MD[2]; Deborah A. Baumgarten, MD[3]; Edward I. Bluth, MD[4]; William H. Bush, Jr., MD[5]; Nancy S. Curry, MD[6]; Gary M. Israel, MD[7]; S. Zafar H. Jafri, MD[8]; Akira Kawashima, MD[9]; Nicholas Papanicolaou, MD[10]; Erick M. Remer, MD[11]; Carl M. Sandler, MD[12]; David B. Spring, MD[13]; Pat Fulgham, MD.[14]

Summary of Literature Review

This narrative addresses appropriate imaging examinations to follow patients who have been treated for renal cell carcinoma by radical nephrectomy or nephron-sparing surgery. It specifically deals with asymptomatic patients; it does not deal with imaging of nononcologic complications of surgery; with patients undergoing systemic therapy for known recurrent renal cell carcinoma; with patients in whom specific symptoms, signs, or laboratory studies suggest recurrent malignancy at a specific site; or with patients whose surgery is known to have left residual tumor [1-6].

Follow-up is important for patients who have had radical or partial nephrectomy for renal cell carcinoma [7]. Although they may be thought to have been initially cured, local or metastatic recurrences may develop in 20%-50% of them and require management. Solitary metastases may occasionally be treated by resection [8,9]. A nonspecific immune approach with cytokines has been used to treat metastatic disease [10,11], yet the use of these agents has been limited by their toxicity as well as generally poor response rates. Recently, several new agents that inhibit vascular endothelial growth factor signaling have shown significant antitumor effects and meaningful clinical benefit [12]. Imaging is essential in evaluating the response to these therapies.

The anatomic location of recurrences clearly dictates the choice of imaging modalities. The tumor may recur in the resection site, especially if the primary is large, high grade, or has a higher tumor (T) stage [4,13,14]. The incidence of tumor recurrence in the resection site is similar or only slightly higher in patients who had partial nephrectomy compared to those who had radical nephrectomy [9,15,16]. More commonly, however, the tumor recurrence appears as distant metastases [17].

[1]Principal Author, Northwestern University, Chicago, Ill; [2]Panel Chair, University of Michigan, Ann Arbor, Mich; [3]Emory University Hospital, Atlanta, Ga; [4]Ochsner Foundation Hospital, New Orleans, La; [5]University of Washington Medical Center, Seattle, Wash; [6]Medical University of South Carolina, Charleston, SC; [7]New York University Medical Center, New York, NY; [8]William Beaumont Hospital, Royal Oak, Mich; [9]Mayo Clinic, Rochester, Minn; [10]Hospital of University of Pennsylvania, Philadelphia, Pa; [11]Cleveland Clinic Foundation, Cleveland, Ohio; [12]UT MD Anderson Cancer Center, Houston, Texas; [13]Kaiser Permanente Medical Center, Oakland, Calif; [14]Urology Clinics of North America, Dallas, Texas, American Urological Association.

Reprint requests to: Department of Quality & Safety, American College of Radiology, 1891 Preston White Drive, Reston, VA 20191-4397.

Several studies have suggested surveillance protocols based on patterns of tumor recurrence, including where and when metastases occur, and the primary tumor's size, stage, and nuclear grade at the time of resection [18,19]. For instance, the risk of metastatic disease after nephrectomy increases with higher stage of the primary tumor [20,21]. In decreasing order of frequency, metastases most commonly appear in lung (with or without mediastinal or hilar nodes) [22], bone, the upper abdomen (including the resection bed, adrenal gland, contralateral kidney and liver), brain, and a multitude of other sites (including skin, spleen, heart, diaphragm, gut, connective tissue, and pancreas) [4,19].

Other characteristics of metastatic disease from renal cell carcinoma are worth consideration. Most lung metastases are (at least early in their history) asymptomatic [2,23]. Metastases in thoracic nodes usually indicate a very short survival [22]. Most bone metastases are symptomatic at the time of discovery; they can appear anywhere in the skeleton [24], but frequently appear in the lumbar spine, thoracic spine, and ribs—that is, the areas likely to be included in chest and abdomen examination [25]. Most recurrences appear within 2-3 years after the initial resection, but they may not occur until decades later [5,26]. Tumor recurrences tend to occur earlier in patients with higher T stages, and those that appear after a long interval appear to be associated with a better prognosis [15]. Therefore it may be argued either that routine follow-up should be limited to only a few years (especially if the chosen modalities are expensive) or that to halt follow-up after a brief period may deprive those patients who might benefit most from treating recurrences of the advantage of an early diagnosis.

Several stage-based surveillance protocols for renal cell carcinoma after radical or partial nephrectomy have been proposed. They can be summarized as follows [1-6,16,19,27,28]:

- **For T1 tumors;** as the risk of metastases is low, most surveillance protocols recommend that history, physical examination, laboratory tests, and a chest radiograph be obtained every 6 to 12 months for 3 years and then yearly until year 5. Others have suggested no imaging if the tumor is less than 2.5 cm. Most protocols do not recommend surveillance with abdominal computed tomography (CT) for patients with T1 tumors.
- **For T2 primary tumors;** most protocols recommend that history, physical examination, laboratory tests and a chest radiograph be obtained annually or every 6 months for 3 years, then annually thereafter till year 5. Protocols vary widely regarding the use of abdominal CT. Some do not recommend CT at all, while others recommend CT at year 2 and year 5. Still others recommend a CT every other year, or annually for 3

years following surgical removal, then annually thereafter.

- **For T3 or T4 primary tumors;** most protocols recommend that history, physical examination, laboratory tests, and a chest radiograph be obtained every 6 months for a few years, then annually thereafter. The vast majority of protocols recommend abdominal CT, with most recommending more frequent (every 3 or 6 months) CT imaging for 3 years after surgery and less frequently (yearly or every other year) thereafter.

Pulmonary Metastases

Given the fact that pulmonary metastases are often asymptomatic, routine imaging of the chest is usually performed. The major modalities used to search for metastases in the chest are the chest x-ray and chest CT [2,3,5,23,29-32]. Certainly, if the chest x-ray is chosen and is positive, CT almost inevitably follows in order to plan for and monitor the results of further therapy. The chest x-ray is less expensive and less likely to display incidental findings unrelated to metastatic disease. CT is more likely to display metastases earlier (in particular, it is more likely to demonstrate metastatic disease when there is just one lesion that might be amenable to resection than when there are several) and is probably more sensitive than chest x-ray in detecting metastases in thoracic spine, ribs, bones of the shoulder, and nodes. But CT is also more likely to display small granulomas that may masquerade as metastases and require further workup. The extra yield from chest CT compared to chest radiography is probably too small to warrant its use in routine surveillance [33]. While a few studies have shown fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography (FDG-PET) to be highly specific in detecting chest metastases, the sensitivity is limited [34-36]. No role for magnetic resonance imaging (MRI), angiography, or ultrasound (US) has been claimed in screening for metastases to the chest.

Abdominal Recurrences

Abdominal recurrences may occur at the surgical site or metastatic to the liver, lymph nodes, adrenal glands, bones, etc. While a few studies have argued against routine imaging of the abdomen in patients after resection of low-stage tumors (T1 and certain T2 tumors) [1,3,5,6], abdominal surveillance is commonly performed with CT. CT is quite sensitive in detecting metastases in the resection site, contralateral kidney, adrenal glands, liver, and bones included in the examination, [4,25,36-40]. MRI should be considered in place of CT in younger patients who will likely require multiple scans and in patients with renal dysfunction or a history of allergy to iodinated contrast. Radiography is likely to be insensitive for all but the largest of masses and bone metastases. FDG-PET can be a useful adjunct to CT or MRI, particularly when a local recurrence is suspected in a renal fossa that may have postoperative and postradiation changes [36,41-43]. Performing separate nuclear medicine liver-spleen, bone, and renal scans is not practical. Angiography is too invasive. Urography is likely to be less sensitive than CT; it may be falsely negative in patients with small intrarenal masses and it is likely to miss all but the largest extrarenal masses. US has demonstrated some success in detecting intra-abdominal recurrences [44], but it has never been shown to be as sensitive as CT, and it is likely to be less sensitive in detecting small resection bed metastases, especially if the nephrectomy has been performed on the left side and if loops of gut occupy the surgical site.

Follow-up of Renal Cell Carcinoma after Ablative Therapies

Energy ablative therapies, such as cryoablation and radiofrequency (RF) ablation, are increasingly used in treating of small renal cell carcinomas as an alternative to partial nephrectomy. These therapies have been shown to be effective and safe [45-49]. Postablative CT and MRI play an important role in the evaluation of the ablation zone, surveillance for residual or recurrent tumor, and identification of procedure-related complications [45-50].

A recent multi-institutional study [51] reported that 63 of 616 patients (10.2%) were found to have residual or recurrent tumor after primary ablation. Residual tumor was defined as enhancement in the vicinity of the treated tumor on the first imaging study after the ablative procedure, and recurrent tumor was defined as enhancement after an initially negative imaging study. Thirty-seven of 46 patients who received salvage ablative therapy for residual or recurrent disease had no further evidence of disease over a mean follow-up period of two years. Seventy percent of the initial treatment failures were detected within the first 3 months after therapy, and 92% were detected within the first 12 months. The proposed surveillance protocol consisted of a minimum of 3 to 4 imaging studies (CT or MRI) in year one after ablative therapy, with studies being performed at months 1, 3, 6 (optional) and 12. The CT or MRI should be a dedicated renal exam using thin cuts and precontrast and postcontrast imaging. The study did not make a specific recommendation for surveillance beyond the first year; although, all the participating institutions reported follow-up imaging with CT or MRI in the range of every 6 to 12 months after year one. The required duration of follow-up is still unknown.

Osseous Metastases

Surveillance for the appearance of metastases to the skeleton might be done by serial radionuclide bone scans [52-55], or it might not be done at all unless the patient develops specific symptoms. Most authors do not suggest routine bone scanning to search for metastases without symptoms [2,3,5,15,40], because the vast majority of bone metastases are symptomatic and bone metastases are not curable. When a bone metastasis is suspected, a bone

scan is preferable to MRI or CT because it can survey the entire skeleton. If the bone scan is positive, a radiograph might be considered to exclude pending fracture. Identification of bone metastases may facilitate treatment for pain relief and prevention of pathologic fracture.

Relatively little has been written regarding the use of radiography or scintigraphy to monitor patients in the postoperative phase. FDG-PET may have a role when CT and/or bone scan findings are equivocal [36]. FDG-PET may reveal bone metastases not detected on bone scan, but false negative results have also been reported [34,56,57].

Brain Metastases

There has been no literature that supports using routine imaging of the brain to search for metastases from renal cell carcinoma in asymptomatic patients [3,5,15].

Summary

Tumor recurrences, whether metastatic or local, are not uncommon after resection of localized renal cell carcinoma. The intensity and length of follow-up in these patients are largely dependent on the stage of the primary tumor. The follow-up generally includes a history and physical examination, CBC, LFTs, and chest radiography. While there is no clear consensus regarding the timing of abdominal CT in routine surveillance, abdominal CT is generally included in the follow-up evaluation of patients after resection. The literature does not support the routine use of bone scans or brain imaging in asymptomatic patients. FDG-PET appears to be a useful adjunct to conventional imaging.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF), also known as nephrogenic fibrosing dermopathy) was first identified in 1997 and has recently generated substantial concern among radiologists, referring doctors and lay people. Until the last few years, gadolinium-based MR contrast agents were widely believed to be almost universally well tolerated, extremely safe and non-nephrotoxic, even when used in patients with impaired renal function. All available experience suggests that these agents remain generally very safe, but recently some patients with renal failure who have been exposed to gadolinium contrast agents (the percentage is unclear) have developed NSF [58-60], a syndrome that can be fatal. Further studies are necessary to determine what the exact relationships are between gadolinium-containing contrast agents, their specific components and stoichiometry, patient renal function and NSF. Current theory links the development of NSF to the administration of relatively high doses (eg, >0.2mM/kg) and to agents in which the gadolinium is least strongly chelated. The FDA has recently issued a "black box" warning concerning these contrast agents (http://www.fda.gov/cder/drug/InfoSheets/HCP/gcca_200705HCP.pdf).

This warning recommends that, until further information is available, gadolinium contrast agents should not be administered to patients with either acute or significant chronic kidney disease (estimated GFR <30 mL/min/1.73m^2), recent liver or kidney transplant or hepato-renal syndrome, unless a risk-benefit assessment suggests that the benefit of administration in the particular patient clearly outweighs the potential risk(s) [59].

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

References

1. Janzen NK, Kim HL, Figlin RA, Belldegrun AS. Surveillance after radical or partial nephrectomy for localized renal cell carcinoma and management of recurrent disease. *Urol Clin North Am* 2003; 30(4):843-852.
2. Levy DA, Slaton JW, Swanson DA, Dinney CP. Stage specific guidelines for surveillance after radical nephrectomy for local renal cell carcinoma. *J Urol* 1998; 159(4):1163-1167.
3. Ljungberg B, Alamdari FI, Rasmuson T, Roos G. Follow-up guidelines for nonmetastatic renal cell carcinoma based on the occurrence of metastases after radical nephrectomy. *BJU Int* 1999; 84(4):405-411.
4. Saidi JA, Newhouse JH, Sawczuk IS. Radiologic follow-up of patients with T1-3a,b,c or T4N+M0 renal cell carcinoma after radical nephrectomy. *Urology* 1998; 52(6):1000-1003.
5. Sandock DS, Seftel AD, Resnick MI. A new protocol for the followup of renal cell carcinoma based on pathological stage. *J Urol* 1995; 154(1):28-31.
6. Stephenson AJ, Chetner MP, Rourke K, et al. Guidelines for the surveillance of localized renal cell carcinoma based on the patterns of relapse after nephrectomy. *J Urol* 2004; 172(1):58-62.
7. Dekernion JB, Belldegrun AS. Renal Tumors. In Walsh PC, et al eds. Campbell's Urology. *W.B. Saunders Co.* Philadelphia, Pa: Campbell's Urology; 1992:1053-1093.
8. Dekernion JB, Ramming KP, Smith RB. The natural history of metastatic renal cell carcinoma: a computer analysis. *J Urol* 1978; 120(2):148-152.

9. Itano NB, Blute ML, Spotts B, Zincke H. Outcome of isolated renal cell carcinoma fossa recurrence after nephrectomy. *J Urol* 2000; 164(2):322-325.
10. Graham SD, Jr. Immunotherapy of renal cell carcinoma. *Semin Urol* 1989; 7(4):215-227.
11. Zisman A, Pantuck AJ, Wieder J, et al. Risk group assessment and clinical outcome algorithm to predict the natural history of patients with surgically resected renal cell carcinoma. *J Clin Oncol* 2002; 20(23):4559-4566.
12. Garcia JA, Rini BI. Recent progress in the management of advanced renal cell carcinoma. *CA Cancer J Clin* 2007; 57(2):112-125.
13. Skinner DG, Colvin RB, Vermillion CD, Pfister RC, Leadbetter WF. Diagnosis and management of renal cell carcinoma. A clinical and pathologic study of 309 cases. *Cancer* 1971; 28(5):1165-1177.
14. Stenzl A, deKernion JB. The natural history of renal cell carcinoma. *Semin Urol* 1989; 7(3):144-148.
15. Hafez KS, Novick AC, Campbell SC. Patterns of tumor recurrence and guidelines for followup after nephron sparing surgery for sporadic renal cell carcinoma. *J Urol* 1997; 157(6):2067-2070.
16. Lau WK, Blute ML, Weaver AL, Torres VE, Zincke H. Matched comparison of radical nephrectomy vs nephron-sparing surgery in patients with unilateral renal cell carcinoma and a normal contralateral kidney. *Mayo Clin Proc* 2000; 75(12):1236-1242.
17. Levine E. Malignant renal parenchymal tumors in adults. In Pollack HM ed. Clinical Urography. *W.B. Saunders* 1990:1246-1291.
18. Bradford TJ, Montie JE, Hafez KS. The role of imaging in the surveillance of urologic malignancies. *Urol Clin North Am* 2006; 33(3):377-396.
19. Chae EJ, Kim JK, Kim SH, Bae SJ, Cho KS. Renal cell carcinoma: analysis of postoperative recurrence patterns. *Radiology* 2005; 234(1):189-196.
20. Bennington JL, Beckwith J. Tumors of the Kidney, Renal Pelvis and Ureter. In: Fascicle 12, Atlas of Tumor Pathology. *AFIP* 1975:93-199.
21. O'Dea M J, Zincke H, Utz DC, Bernatz PE. The treatment of renal cell carcinoma with solitary metastasis. *J Urol* 1978; 120(5):540-542.
22. Land EK. Renal cell carcinoma presenting with metastases to pulmonary hilar nodes. *J Urol* 1977; 118(4):543-546.
23. Coppage L, Shaw C, Curtis AM. Metastatic disease to the chest in patients with extrathoracic malignancy. *J Thorac Imaging* 1987; 2(4):24-37.
24. Swanson DA, Orovan WL, Johnson DE, Giacco G. Osseous metastases secondary to renal cell carcinoma. *Urology* 1981; 18(6):556-561.
25. Arkless R. Renal Carcinoma: How It Metastasizes. *Radiology* 1965; 84:496-501.
26. Kradjian RM, Bennington JL. Renal Carcinoma Recurrent 31 Years After Nephrectomy. *Arch Surg* 1965; 90:192-195.
27. Chin AI, Lam JS, Figlin RA, Belldegrun AS. Surveillance strategies for renal cell carcinoma patients following nephrectomy. *Rev Urol* 2006; 8(1):1-7.
28. Skolarikos A, Alivizatos G, Laguna P, de la Rosette J. A review on follow-up strategies for renal cell carcinoma after nephrectomy. *Eur Urol* 2007; 51(6):1490-1501.
29. Bergman SM, Lippert M, Javadpour N. The value of whole lung tomography in the early detection of metastatic disease in patients with renal cell carcinoma and testicular tumors. *J Urol* 1980; 124(6):860-862.
30. Davis SD. CT evaluation for pulmonary metastases in patients with extrathoracic malignancy. *Radiology* 1991; 180(1):1-12.
31. Kutty K, Varkey B. Incidence and distribution of intrathoracic metastases from renal cell carcinoma. *Arch Intern Med* 1984; 144(2):273-276.
32. Lokich JJ, Harrison JH. Renal cell carcinoma: natural history and chemotherapeutic experience. *J Urol* 1975; 114(3):371-374.
33. Lim DJ, Carter MF. Computerized tomography in the preoperative staging for pulmonary metastases in patients with renal cell carcinoma. *J Urol* 1993; 150(4):1112-1114.
34. Jadvar H, Kherbache HM, Pinski JK, Conti PS. Diagnostic role of [F-18]-FDG positron emission tomography in restaging renal cell carcinoma. *Clin Nephrol* 2003; 60(6):395-400.
35. Majhail NS, Urbain JL, Albani JM, et al. F-18 fluorodeoxyglucose positron emission tomography in the evaluation of distant metastases from renal cell carcinoma. *J Clin Oncol* 2003; 21(21):3995-4000.
36. Kang DE, White RL, Jr., Zuger JH, Sasser HC, Teigland CM. Clinical use of fluorodeoxyglucose F 18 positron emission tomography for detection of renal cell carcinoma. *J Urol* 2004; 171(5):1806-1809.
37. Alter AJ, Uehling DT, Zwiebel WJ. Computed tomography of the retroperitoneum following nephrectomy. *Radiology* 1979; 133(3 Pt 1):663-668.
38. Bernardino ME, deSantos LA, Johnson DE, Bracken RB. Computed tomography in the evaluation of post-nephrectomy patients. *Radiology* 1979; 130(1):183-187.
39. Marano I, Stagni V, Tovecci F, Covello M, Porta G. [Computed tomography in the follow-up of patients nephrectomized for adenocarcinoma]. *Radiol Med (Torino)* 1993; 85(1-2):90-95.
40. McClennan BL, Deyoe LA. The imaging evaluation of renal cell carcinoma: diagnosis and staging. *Radiol Clin North Am* 1994; 32(1):55-69.
41. Brouwers AH, Dorr U, Lang O, et al. 131 I-cG250 monoclonal antibody immunoscintigraphy versus [18 F]FDG-PET imaging in patients with metastatic renal cell carcinoma: a comparative study. *Nucl Med Commun* 2002; 23(3):229-236.
42. Ramdave S, Thomas GW, Berlangieri SU, et al. Clinical role of F-18 fluorodeoxyglucose positron emission tomography for detection and management of renal cell carcinoma. *J Urol* 2001; 166(3):825-830.
43. Safaei A, Figlin R, Hoh CK, et al. The usefulness of F-18 deoxyglucose whole-body positron emission tomography (PET) for re-staging of renal cell cancer. *Clin Nephrol* 2002; 57(1):56-62.
44. Bernardino ME, Green B, Goldstein HM. Ultrasonography in the evaluation of post-nephrectomy renal cancer patients. *Radiology* 1978; 128(2):455-458.
45. Atwell TD, Farrell MA, Callstrom MR, et al. Percutaneous cryoablation of 40 solid renal tumors with US guidance and CT monitoring: initial experience. *Radiology* 2007; 243(1):276-283.
46. Gill IS, Remer EM, Hasan WA, et al. Renal cryoablation: outcome at 3 years. *J Urol* 2005; 173(6):1903-1907.
47. McDougal WS, Gervais DA, McGovern FJ, Mueller PR. Long-term followup of patients with renal cell carcinoma treated with radio frequency ablation with curative intent. *J Urol* 2005; 174(1):61-63.
48. Rukstalis DB, Khorsandi M, Garcia FU, Hoenig DM, Cohen JK. Clinical experience with open renal cryoablation. *Urology* 2001; 57(1):34-39.
49. Zagoria RJ, Hawkins AD, Clark PE, et al. Percutaneous CT-guided radiofrequency ablation of renal neoplasms: factors influencing success. *AJR* 2004; 183(1):201-207.
50. Wile GE, Leyendecker JR, Krehbiel KA, Dyer RB, Zagoria RJ. CT and MR imaging after imaging-guided thermal ablation of renal neoplasms. *Radiographics* 2007; 27(2):325-339; discussion 339-340.
51. Matin SF, Ahrar K, Cadeddu JA, et al. Residual and recurrent disease following renal energy ablative therapy: a multi-institutional study. *J Urol* 2006; 176(5):1973-1977.
52. Blacher E, Johnson DE, Haynie TP. Value of routine radionuclide bone scans in renal cell carcinoma. *Urology* 1985; 26(5):432-434.
53. Chancellor MB, Konnak JW, Grossman HB. Diagnostic value of routine bone scintigraphy renal imaging in renal cell carcinoma. *Urology* 1989; 33(5):440-442.
54. Cole AT, Mandell J, Fried FA, Stabb EV. The place of bone scan in the diagnosis of renal cell carcinoma. *J Urol* 1975; 114(3):364-365.
55. Rosen PR, Murphy KG. Bone scintigraphy in the initial staging of patients with renal-cell carcinoma: concise communication. *J Nucl Med* 1984; 25(3):289-291.

56. Seto E, Segall GM, Terris MK. Positron emission tomography detection of osseous metastases of renal cell carcinoma not identified on bone scan. *Urology* 2000; 55(2):286.
57. Wu HC, Yen RF, Shen YY, Kao CH, Lin CC, Lee CC. Comparing whole body 18F-2-deoxyglucose positron emission tomography and technetium-99m methylene diphosphate bone scan to detect bone metastases in patients with renal cell carcinomas - a preliminary report. *J Cancer Res Clin Oncol* 2002; 128(9):503-506.
58. Broome DR, Girguis MS, Baron PW, Cottrell AC, Kjellin I, Kirk GA. Gadodiamide-associated nephrogenic systemic fibrosis: why radiologists should be concerned. *AJR* 2007; 188(2):586-592.
59. Kanal E, Barkovich AJ, Bell C, et al. ACR guidance document for safe MR practices: 2007. *AJR* 2007; 188(6):1447-1474.
60. Sadowski EA, Bennett LK, Chan MR, et al. Nephrogenic systemic fibrosis: risk factors and incidence estimation. *Radiology* 2007; 243(1):148-157.