American College of Radiology
ACR Appropriateness Criteria®
Staging of Renal Cell Carcinoma

Variant 1: **Renal cell carcinoma. No contraindication to either iodinated CT contrast or gadolinium-based MR intravenous contrast. Staging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI abdomen and pelvis without and with IV contrast	Usually Appropriate	O
MRI abdomen without and with IV contrast	Usually Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CT abdomen with IV contrast	Usually Appropriate	☢☢☢
CT chest with IV contrast	Usually Appropriate	☢☢☢
Radiography chest	May Be Appropriate	☢
Bone scan whole body with SPECT or SPECT/CT area of interest	May Be Appropriate	☢☢☢
CT head with IV contrast	May Be Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	May Be Appropriate (Disagreement)	☢☢☢☢
CT abdomen without and with IV contrast	May Be Appropriate (Disagreement)	☢☢☢☢
US abdomen	Usually Not Appropriate	O
US abdomen with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRI head without IV contrast	Usually Not Appropriate	O
MRU without and with IV contrast	Usually Not Appropriate	O
MRU without IV contrast	Usually Not Appropriate	O
Bone scan whole body	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen without IV contrast	Usually Not Appropriate	☢☢☢
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CT chest without IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head without IV contrast	Usually Not Appropriate	☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
Fluoride PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢

Variant 2: **Renal cell carcinoma. Contraindication to both iodinated CT and gadolinium-based MR intravenous contrast. Staging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI abdomen and pelvis without IV contrast	Usually Appropriate	O
MRI abdomen without IV contrast	Usually Appropriate	O
CT chest without IV contrast	Usually Appropriate	☢☢☢
Radiography chest	May Be Appropriate	☢
MRI head without IV contrast	May Be Appropriate	O
Bone scan whole body	May Be Appropriate	☢☢☢
Bone scan whole body with SPECT or SPECT/CT area of interest	May Be Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
CT abdomen without IV contrast	May Be Appropriate (Disagreement)	☢☢☢
US abdomen	Usually Not Appropriate	O
US abdomen with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRU without and with IV contrast	Usually Not Appropriate	O
MRU without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen with IV contrast	Usually Not Appropriate	☢☢☢
CT chest with IV contrast	Usually Not Appropriate	☢☢☢
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
Fluoride PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢

Variant 3: **Renal cell carcinoma. Contraindication only to iodinated CT intravenous contrast. Staging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI abdomen and pelvis without and with IV contrast	Usually Appropriate	O
MRI abdomen without and with IV contrast	Usually Appropriate	O
CT chest without IV contrast	Usually Appropriate	☢☢☢
Radiography chest	May Be Appropriate	☢
Bone scan whole body with SPECT or SPECT/CT area of interest	May Be Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
CT abdomen without IV contrast	May Be Appropriate	☢☢☢
US abdomen	Usually Not Appropriate	O
US abdomen with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRI head without IV contrast	Usually Not Appropriate	O
MRU without and with IV contrast	Usually Not Appropriate	O
MRU without IV contrast	Usually Not Appropriate	O
Bone scan whole body	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen with IV contrast	Usually Not Appropriate	☢☢☢
CT chest with IV contrast	Usually Not Appropriate	☢☢☢
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢☢
Fluoride PET/CT skull base to mid-thigh	Usually Not Appropriate	☢☢☢

STAGING OF RENAL CELL CARCINOMA

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Summary of Literature Review

Introduction/Background

Renal cancer is the third most common urologic cancer and accounts for 1% to 3% of all adult malignancies. Renal cell carcinoma (RCC) represents the vast majority (85%-90%) of all malignant renal tumors in adults. It is estimated that there will be approximately 76,080 new cases of renal cancers and more than 13,780 renal cancer–related deaths in the United States in 2021 [1,2].

The incidence of RCC is reported to be higher in men, with a 2.02% lifetime risk, compared with 1.03% in women. Various potential risk factors have been reported for RCC including smoking, obesity, high blood pressure, advanced renal disease, exposure to certain chemicals such as trichloroethylene, and a family history of renal cancer. African Americans are at a higher risk of developing renal malignancies, although the cause for this increased risk is not yet known. Although the vast majority of RCCs are sporadic, approximately 5% of these tumors are hereditary. There are numerous hereditary renal cancer syndromes, and several of these have autosomal dominant inheritance, including von Hippel-Lindau disease, hereditary leiomyomatosis and RCC, Birt-Hogg-Dubé syndrome, and hereditary papillary renal cancer. Among these, the most common hereditary renal cancer syndrome is von Hippel-Lindau disease, and the prevalence of RCC in these patients varies from 25% to 45%.

Recent advances in the molecular cytogenetics of RCC have significantly enhanced understanding of the pathogenesis, tumor biology, management, and prognosis of this highly heterogeneous malignancy. In 2016, the World Health Organization published the revised classification of renal tumors. There are more than 14 histological subtypes of RCC, but the majority of RCC belong to 3 histological variants, namely clear-cell RCC (75%), papillary RCC (10%-15%), and chromophobe RCC (4%-6%) [3].

Tumor stage is an extremely important prognostic factor in RCC. Patients with stage I localized RCC have an 81% 5-year survival rate compared with just an 8% 5-year survival rate for those with stage IV RCC. Staging of RCC is performed using the TNM staging system, which was developed by the American Joint Committee on Cancer (AJCC) [4].

T1 tumors measure ≤7 cm in greatest dimension and are limited to the kidney. TI tumors are further subdivided into T1a (tumor ≤4 cm) and T1b (tumor >4 cm but ≤7 cm). T2 tumors measure >7 cm at the greatest dimension and are also limited to the kidney. Similar to T1 tumors, T2 tumors are subdivided based on size into T2a (tumor >7 cm but ≤10 cm) and T2b (tumor >10 cm). T3 tumors extend beyond the kidney and may extend into renal vein, inferior vena cava (IVC), or perirenal fat but not into the ipsilateral adrenal gland and not beyond Gerota fascia. T3 tumors are divided into T3a (involvement of renal vein, pelvicalyceal system, perirenal fat, renal sinus fat), T3b (involvement of the IVC below the diaphragm), and T3c (involvement of the IVC above the diaphragm or invasion of the wall of the IVC). T4 tumors are those that involve the ipsilateral adrenal gland and/ or extend beyond Gerota fascia. N0 indicates absence of nodal involvement, whereas N1 refers to presence of regional nodal involvement. M0 indicates absence of metastatic involvement, whereas M1 designation refers to presence of distant metastases. Stage I disease indicates T1N0M0, whereas stage II disease refers to the presence of T2N0M0. Stage III disease is

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presence of any nodal metastases (N1) and/ or T3 tumor. Stage IV disease is the presence of any distant metastases (M1) and/or presence of T4 tumor.

Curative treatment for RCC may be accomplished with surgical resection. Partial nephrectomy is the preferred treatment option for small T1 RCC, especially because it is associated with lower risk of renal failure and cardiovascular mortality compared to radical nephrectomy. However, it has been reported that incidence of complications such as postoperative bleeding and urinary leaks may be high in partial nephrectomy. Hence, urologists carefully select patients for partial nephrectomy using preoperative scoring systems, such as the Preoperative Aspects and Dimensions Used for Anatomic assessment score, Renal Nephrometry Score, and Centrality Index. Although a full description of these scoring systems is beyond the scope of this manuscript, urologists consider various factors for surgical planning including size of the tumor and the number of lesions (such as presence of multiple and/or bilateral tumors). The location of the tumor is another important criteria. Factors such as tumor location in the upper/mid/lower pole of the kidney, tumor location in the anterior versus posterior renal cortex, location in the medial or lateral rim, and presence of exophytic versus endophytic tumor may impact the decision to perform partial nephrectomy. Furthermore, tumor involvement of renal sinus and perinephric fat, involvement of renal vein and IVC, tumor extension into adjacent organs, and presence of nodal and distant metastases are critical information needed for treatment planning. Although partial nephrectomy may be the preferred curative option in many patients, active surveillance and local ablative therapies are being increasingly considered in carefully selected patients in the management of small localized T1 RCC [5].

Locally advanced T2 to T4 RCC and complex tumors not amenable for partial nephrectomy approach may benefit from radical nephrectomy. Metastatic disease at presentation varies with the patient series but typically occurs in approximately 1 in 10 patients [6,7]. The most common sites of distant metastases, in descending order, are the lungs, bone, retroperitoneal and mediastinal nodes, liver, brain, or multiple sites [8,9].

Radical nephrectomy with metastasectomy remains an option for carefully selected patients with oligo-metastases. Similarly, cytoreductive nephrectomy may be considered even in advanced stage RCC. However, many patients with advanced stage RCC present with multifocal metastatic disease, warranting a multidisciplinary approach. Better understanding of RCC tumor biology has paved the way for the development of numerous FDA-approved therapeutic options for advanced stage RCC including targeted therapy and immunotherapy.

Imaging plays an important role in the staging of RCC [10]. In this document, we provide an update on the appropriate use of imaging examinations for initial staging of known RCC.

Special Imaging Considerations

CT urography (CTU) is an imaging study that is tailored to improve visualization of both the upper and lower urinary tracts. There is variability in the specific parameters, but it usually involves unenhanced images followed by intravenous (IV) contrast-enhanced images, including nephrographic and excretory phases acquired at least 5 minutes after contrast injection. Alternatively, a split-bolus technique uses an initial loading dose of IV contrast and then obtains a combined nephrographic-excretory phase after a second IV contrast dose; some sites include arterial phase. CTU should use thin-slice acquisition. Reconstruction methods commonly include maximum intensity projection or 3-D volume rendering. For the purposes of this document, we make a distinction between CTU and CT abdomen and pelvis without and with IV contrast. CT abdomen and pelvis without and with IV contrast is defined as any protocol not specifically tailored for evaluation of the upper and lower urinary tracts and without both the precontrast and excretory phases.

MR urography (MRU) is also tailored to improve imaging of the urinary system. Unenhanced MRU relies upon heavily T2-weighted imaging of the intrinsic high signal intensity from urine for evaluation of the urinary tract. IV contrast is administered to provide additional information regarding obstruction, urothelial thickening, focal lesions, and stones. A contrast-enhanced T1-weighted series should include corticomedullary, nephrographic, and excretory phases. Thin-slice acquisition and multiplanar imaging should be obtained. For the purposes of this document, we make a distinction between MRU and MRI abdomen and pelvis without and with IV contrast. MRI abdomen and pelvis without and with IV contrast is defined as any protocol not specifically tailored for evaluation of the upper and lower urinary tracts, without both the precontrast and excretory phases, and without heavily T2-weighted images of the urinary tract.

Discussion of Procedures by Variant

Variant 1: Renal cell carcinoma. No contraindication to either iodinated CT contrast or gadolinium-based MR intravenous contrast. Staging.

Bone Scan Whole Body

The prevalence of osseous metastases for localized RCC has been shown to be low in patients without symptoms (ie, bone pain) or without laboratory abnormalities suggestive of osseous metastases (ie, elevated serum alkaline phosphatase level) [11,12]. Furthermore, the sites commonly involved by osseous metastases, such as the thoracolumbar spine and ribs, are located in areas covered by chest and abdominal imaging. Thus, even though bone scanning can be helpful to confirm clinically or radiographically suspected metastatic disease, current guidelines from the European Association of Urology (EAU) and National Comprehensive Cancer Network (NCCN) do not support its routine use in the initial staging of asymptomatic RCC [5,13]. However, in patients with RCC with symptoms suspicious for bone metastases, bone scan may be useful.

Bone Scan Whole Body with SPECT or SPECT/CT Area of Interest

The prevalence of osseous metastases for localized RCC has been shown to be low in patients without symptoms (ie, bone pain) or without laboratory abnormalities suggestive of osseous metastases (ie, elevated serum alkaline phosphatase level) [11,12]. Furthermore, the sites commonly involved by osseous metastases, such as the thoracolumbar spine and ribs, are located in areas covered by chest and abdominal imaging. Thus, even though bone scanning can be helpful to confirm clinically or radiographically suspected metastatic disease, current guidelines do not support its routine use in the initial staging of asymptomatic RCC [5,13].

In patients with RCC with symptoms suspicious for bone metastases, bone scan may be useful. If the bone scan shows areas of abnormal radiotracer uptake suspicious for osseous metastases, single-photon emission CT (SPECT) fused with CT can be used to provide detailed anatomic localization of the abnormal radiotracer uptake and further improve the characterization of the nature of the abnormality [14].

CT Abdomen

Preoperative imaging of RCC provides critical information on staging and serves as a roadmap to the surgeon. Both CT and MRI are comparable in staging of the primary tumor [15,16]. CT of the abdomen with IV contrast is considered in all major guidelines as an adequate method for staging of RCC, including the guidelines from the EAU and NCCN [5,13]. Use of IV contrast helps in the diagnosis and staging of the RCC [14,15,17-27]. Acquisition of nephrographic phase images is vital and most important in the detection and characterization of RCC. Corticomedullary phase images and excretory phase images are optional and may be helpful in differentiating RCC subtypes, distinguishing RCC from urothelial tumors and in providing complementary information on the vasculature and tumor extension into pelvicalyceal system.

As alluded to before, the size of the RCC, which is localized to the kidney, is important for the T stage classification in the AJCC TNM staging system because localized tumors measuring ≤7 cm in greatest dimension are classified as T1 compared with T2 tumors, which measure >7 cm in greatest dimension. Numerous studies have reported that CT is accurate for evaluating the size of RCC and highly correlates with the tumor size on surgical pathology, although discrepancies may occur [28-30]. CT is also helpful in detecting T3 and T4 tumors, although it is acknowledged that accurate identification of features such as perinephric or renal sinus fat invasion may be difficult on imaging [3,31,32].

Extension into the perinephric fat is difficult to discriminate from nonspecific perinephric stranding due to edema, vascular engorgement, or fibrosis. High-resolution CT using thin sections appears to improve detection of perinephric infiltration, although false positives are common [15,16,33]. Various authors have reported 85% to 93% sensitivity and 32% to 96% specificity for the detection of perinephric invasion on IV contrast-enhanced CT abdomen [33-35]. In a study involving 117 patients, CT abdomen was reported to have a sensitivity of 59% to 88% and a specificity of 71% to 93% in detecting stage T3a RCC [36]. In particular, CT had a 71% to 88% sensitivity and 71% to 79% specificity for renal sinus fat invasion, a 68% to 83% sensitivity and a 72% to 76% specificity for perinephric fat invasion, and a 59% to 69% sensitivity and a 91% to 93% specificity for renal vein invasion [36]. In a more recent study, 96 patients with 100 pathologically proven RCC, CT was reported to have an 86% sensitivity and 88% specificity for renal sinus fat invasion and an approximately 86% sensitivity and 97% specificity for renal vein invasion [37]. However, CT only had a modest 77% sensitivity and 72% specificity for detecting perinephric fat invasion in this study, emphasizing the difficulties in differentiating nontumoral causes for perinephric soft tissue stranding, from true tumor perinephric fat invasion [37].

It has been reported that the presence of enhancing soft tissue nodule in the perinephric fat on CT may be a helpful sign for the assessment of perinephric fat invasion. Landman et al [38] reported that the presence of enhancing perinephric soft tissue nodule had an 87% accuracy in predicting perinephric fat invasion compared with the CT finding of perinephric soft tissue stranding, which only had a 56% accuracy. However, the sensitivity of enhancing perinephric soft tissue nodule in detection of perinephric fat invasion is relatively low (31%) [38].

CT has an excellent sensitivity for detecting ipsilateral adrenal involvement in RCC (T4 tumors), but the specificity varies from 76% to 95%. One study involving 229 patients with RCC reported that CT had a 100% sensitivity for ipsilateral adrenal involvement in RCC, but only a 76% specificity [39]. However, Blakely et al [40] reported a 100% sensitivity and a 94% specificity for CT in identifying adrenal involvement. Similar findings have been reported by other authors. In another study involving 579 patients, CT was reported to have a 100% negative predictive value, a 100% sensitivity, and a 95% specificity for identifying adrenal involvement [41].

Assessment of RCC nodal metastases on CT is limited [42]. This is due to the fact that CT uses size criteria for nodal metastasis (size >1 cm in short-axis), but this leads to underestimation of disease, resulting in false negatives in the presence of micrometastases in nodes <1 cm in size. Furthermore, false positives are also often seen because of presence of reactive adenopathy, with nodes >1 cm in size. CT is accurate in detecting distant metastases in the abdomen. RCC visceral metastases may occur at various organs including liver, pancreas, adrenals, and contralateral kidney. RCC metastases tend to be hypervascular, and some authors have suggested that arterial phase imaging can be useful to accurately detect the extent of distant metastases [43-46].

CT Abdomen and Pelvis

Preoperative imaging of RCC provides critical information on staging and serves as a roadmap to the surgeon. Both CT and MRI are comparable in staging of the primary tumor [15,16]. Advantages of CT include rapid acquisition time that may translate to better patient compliance and high spatial resolution. Hence, it is often the most commonly used modality for this indication. CT abdomen without and with IV contrast is typically performed for charactering a renal mass as RCC and staging the tumor. Acquisition of nephrographic phase images is vital and most important in the detection and characterization of RCC. Corticomedullary phase images and excretory phase images are optional and may be helpful in differentiating RCC subtypes, distinguishing RCC from urothelial tumors and in providing complementary information on the vasculature and tumor extension into pelvicalyceal system.

As alluded to before, the size of the RCC that is localized to the kidney is important for the T stage classification in the AJCC TNM staging system because localized tumors measuring ≤7 cm in greatest dimension are classified as T1 compared with T2 tumors, which measure >7 cm in greatest dimension. Numerous studies have reported that CT is fairly accurate for evaluating the size of RCC and highly correlates with the tumor size on surgical pathology, although discrepancies may occur [28-30]. CT is also helpful in detecting T3 and T4 tumors, although it is acknowledged that accurate identification of features such as perinephric or renal sinus fat invasion may be difficult on imaging [3,31,32].

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Although CT of the abdomen with IV contrast is considered in all major guidelines as an adequate method for the staging of RCC, imaging of the pelvis for RCC staging is considered optional in the guidelines [5,13]. There is no relevant literature with high-quality evidence regarding the use of CT of the pelvis in the staging of RCC. Although it is likely that CT pelvis may not offer additional information in most patients with early stage RCC, pelvic imaging can be helpful in patients with more advanced RCC, in whom metastatic spread is suspected [47,48].

CT Chest

Chest imaging is indicated in the staging of RCC, given that lungs are one of the most common sites of metastases in RCC [5,13]. There is a lack of literature that have directly compared the accuracy of chest CT with chest radiography for detecting pulmonary metastases in the initial staging of RCC. However, limited data have demonstrated that CT is more sensitive than radiography for the detection of pulmonary metastases from RCC [49]. Hence, CT chest with IV contrast is recommended by the current NCCN guidelines [13].

Apart from identifying pulmonary metastases, chest CT has a high sensitivity for the detection of hilar and mediastinal nodal metastases from RCC [50]. Although it is generally accepted that CT has a high sensitivity for detecting pulmonary nodules, it should be noted that presence of small subcentimeter pulmonary nodules does not equate to pulmonary metastases. Most patients with small T1a RCCs are unlikely to have pulmonary metastases. Prior studies have reported that the risk of metastases is highly correlated with size of the tumor and is virtually nonexistent in tumors <2 cm in size, occurs <1% in tumors of 2 to 3 cm, and occurs approximately 1% to 2% for lesions 3 to 4 cm [51-53]. Hence, the presence of small subcentimeter pulmonary nodules in T1a RCCs is often likely to be a false-positive finding (ie, intrapulmonary lymph nodes and granulomas) but can lead to further unnecessary and potentially invasive investigations.

Larcher et al [54] evaluated the role of staging chest CT in 1,946 patients with RCC. Of the 1,946 patients, 119 had a positive chest CT (6%). Based on multivariable logistic regression model, the authors predicted that patients with RCCs >cTIb, cN1, and systemic symptoms of anemia and thrombocytopenia are more likely to benefit from preoperative chest CT rather than having it performed for all patients with RCC [54]. A more recent study involving 1,082 patients with RCC provided external validation of the Larcher nomogram and reported that the risk of positive chest was <1% in patients without any systemic symptoms and tumor size ≤4 cm [55]. Further large-scale prospective studies would be helpful in deciding when to perform CT chest versus chest radiography in the initial imaging of RCC.

CT Head

Most patients with metastases to the central nervous system are symptomatic. Thus, current guidelines from the EAU and NCCN do not support routine imaging of the brain to search for metastases in asymptomatic patients in the initial staging of RCC. Brain imaging should be performed only in cases with suggestive signs or symptoms [5,13]. Recent studies indicate that up to 4% of patients with advanced, metastatic RCC may harbor asymptomatic brain metastasis [56,57].

Hence, routine brain imaging with IV contrast may be considered in patients with advanced, metastatic RCC, even if they are asymptomatic [56,57].

CTU
There is no relevant literature suggesting that CTU offers any additional benefit over conventional CT of the abdomen in the initial staging of RCC, and thus, this method is not included in the guidelines from the EAU and NCCN [5,13].

FDG-PET/CT Skull Base to Mid-Thigh
Fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG)-PET/CT has a limited role in the diagnosis and local staging of RCC [58]. Differentiating renal tumor from background normal renal tissue can be difficult because of the renal excretion of FDG. Furthermore, RCC is reported to have variable FDG avidity, limiting its utility. Nakanishi et al [59] reported a 56% sensitivity, a 67% specificity, a 15% positive predictive value, a 57% negative predictive value, and a 65% accuracy for FDG-PET in the staging of RCC. A recent clinical trial from Turkey involving 62 patients with RCC reported an 84% accuracy for contrast-enhanced FDG-PET/CT in staging RCC [60]. However, further studies are warranted before PET/CT can be used in the routine initial staging of RCC. At present, given the paucity of literature to support the use of FDG-PET/CT, the guidelines from the EAU and NCCN do not recommend routine FDG-PET/CT in the initial staging of RCC [5,13].

Fluoride PET/CT Skull Base to Mid-Thigh
Preliminary results for other PET tracers are also becoming available. In a small prospective study of 10 patients with metastatic RCC, 18F-sodium fluoride (NaF) PET/CT was found to be significantly more sensitive for the detection of RCC skeletal metastases than Tc-99m bone scintigraphy or CT, with sensitivities of 100%, 29%, and 46%, respectively. CT and Tc-99m bone scintigraphy in this study identified only 65% of the metastases detected by fluoride PET/CT [61]. However, given the paucity of litereature for utility of fluoride PET/CT in the initial staging of RCC, current guidelines from the EAU and NCCN do not support routine fluoride PET/CT to search for metastases in asymptomatic patients in the initial staging of RCC [5,13].

MRI Abdomen and Pelvis
MRI of the abdomen without and with IV contrast is considered a reliable method for the staging of RCC. Various MR sequences, including T2-weighted, chemical shift T1-weighted, contrast-enhanced T1-weighted, and diffusion-weighted images, are typically obtained for the staging of RCC. In a study involving 40 patients with RCC, MRI was reported to have an accuracy of 81% to 86% for T staging [62]. Breath-hold MRI showing a lack of perinephric fat involvement is reported to have a high negative predictive value for no perinephric tumor invasion [63].

In a study of 73 RCCs, Roy et al [64] showed that the presence of a pseudocapsule on MRI had an accuracy of 93% for clear-cell carcinomas in separating T1/T2 tumors from T3a tumors. Lal et al [65] performed a prospective observational study in 50 patients with RCC, comparing MRI with histopathological findings. In this study, MRI was reported to have a 90% agreement with histopathology for detecting perirenal extension and a 97% agreement with histopathology for detecting tumor extension beyond Gerota fascia [65]. Both contrast-enhanced multidetector CT and MRI are helpful in detecting venous involvement, particularly in the main renal vein and the IVC [33,66].

Increased diameter of the IVC and renal vein, presence of tumor signal both inside and outside the vessel wall, altered signal intensity in the vessel wall, presence of flow around the tumor thrombus, and mobility in different phases are some of the MRI features that are helpful in detecting venous involvement [67,68]. Bland thrombus featuring a uniform signal intensity and lack of enhancement after gadolinium can be distinguished from tumor thrombus, which exhibits intermediate or high signal intensity, heterogeneous intensity, and, more reliably, the presence of small vessels. In a recent study involving 81 patients with RCC, MRI was reported to have a 92% sensitivity, an 86% specificity, an 89% positive predictive value, and a 91% negative predictive value for identifying IVC wall invasion [69]. Pitfalls of MRI include the potential for large tumors to compress the vena cava and cause flow-related artifacts. Such artifacts can be reduced with appropriate saturation pulses.

Although MRI of the abdomen with IV contrast is considered in all major guidelines as an adequate method for the staging of RCC, imaging the pelvis for RCC staging is considered optional in the guidelines [5,13]. There is no relevant literature with high-quality evidence regarding the use of MRI of the pelvis in the staging of RCC. Although it is likely that MRI pelvis may not offer additional information in most patients with early stage RCC, pelvic imaging can be helpful in patients with more advanced RCC, in whom metastatic spread is suspected [47,48].

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MRI Head

Most patients with metastases to the central nervous system are symptomatic. Thus, current guidelines do not support routine imaging of the brain to search for metastases in asymptomatic patients in the initial staging of RCC. Brain imaging with contrast should be performed only in cases with suggestive signs or symptoms [5,13].

Recent studies indicate that up to 4% of patients with advanced, metastatic RCC may harbor asymptomatic brain metastasis [56,57]. Hence, routine brain imaging with IV contrast may be considered in patients with advanced, metastatic RCC, even if they are asymptomatic [56,57].

MRU

There is no relevant literature suggesting that MRU offers any additional benefit over conventional MRI of the abdomen in the initial staging of RCC, and thus, this method is not included in the guidelines from the EAU and NCCN [5,13].

Radiography Chest

The lung is the most common site of metastases in patients with RCC presenting with synchronous metastases. Although the incidence of metastases in RCC <4 cm is low (approximately 1%-2%), it has been reported that 20% to 30% of T1a tumors may have potentially aggressive histologic features. Hence, chest radiography is usually performed in the staging of RCC [13]. However, CT is more sensitive than radiography for the detection of pulmonary metastases from RCC during staging. In addition to a high sensitivity for the detection of pulmonary metastases, chest CT has a high sensitivity for the detection of intrathoracic nodal metastases from RCC. Therefore, in patients with higher risk of pulmonary metastases (such as tumor >4 cm, cN1, presence of systemic symptoms), chest CT is preferred [54,55].

US Abdomen

Ultrasound (US) can be useful in the characterization of renal masses because it can help in differentiating solid and cystic renal masses. However, it is seldom used in the staging of RCC because of its relatively poor performance in evaluating local tumor spread and metastatic disease [70,71]. US can be challenging to perform in patients with a high body mass index. Additional challenges in the use of US may be related to incomplete visualization of the mass, acoustic shadowing from partially calcified cysts or masses, variability in echogenicity of hemorrhagic cysts, and poor sensitivity in diagnosing isoechoic small renal tumors. There is no relevant literature suggesting that US offers any additional benefit over conventional CT or MRI of the abdomen in the initial staging of RCC, and thus, this method is not included in the guidelines from the EAU and NCCN [5,13]. However, intraoperative US may be helpful in performing partial nephrectomy, especially in patients with endophytic renal tumors [72,73].

Variant 2: Renal cell carcinoma. Contraindication to both iodinated CT and gadolinium-based MR intravenous contrast. Staging.

Bone Scan Whole Body

The prevalence of osseous metastases for localized RCC has been shown to be low in patients without symptoms (ie, bone pain) or without laboratory abnormalities suggestive of osseous metastases (ie, elevated serum alkaline phosphatase level) [11,12]. Furthermore, the sites commonly involved by osseous metastases, such as the thoracolumbar spine and ribs, are located in areas covered by chest and abdominal imaging. Thus, even though bone scanning can be helpful to confirm clinically or radiographically suspected metastatic disease, current guidelines do not support its routine use in the initial staging of asymptomatic RCC [5,13].

Bone Scan Whole Body with SPECT or SPECT/CT Area of Interest

The prevalence of osseous metastases for localized RCC has been shown to be low in patients without symptoms (ie, bone pain) or without laboratory abnormalities suggestive of osseous metastases (ie, elevated serum alkaline phosphatase level) [11,12]. Furthermore, the sites commonly involved by osseous metastases, such as the thoracolumbar spine and ribs, are located in areas covered by chest and abdominal imaging. Thus, even though bone scanning can be helpful to confirm clinically or radiographically suspected metastatic disease, current guidelines do not support its routine use in the initial staging of asymptomatic RCC [5,13].

In patients with RCC with symptoms suspicious for bone metastases, bone scan may be useful. If the bone scan shows areas of abnormal radiotracer uptake suspicious for osseous metastases, SPECT fused with CT can be used to provide detailed anatomic localization of the abnormal radiotracer uptake and further improve the characterization of the nature of the abnormality [14].

CT Abdomen

Preoperative imaging of RCC provides critical information on staging and serves as a roadmap to the surgeon. Both CT and MRI are comparable in the staging of the primary tumor [15,16]. Advantages of CT include rapid acquisition time, which may translate to better patient compliance, and high spatial resolution. Hence it is often the most commonly used modality for this indication. CT abdomen without and with IV contrast is typically performed for charactering a renal mass as RCC and staging the tumor. However, in patients with contraindications to iodinated contrast, only unenhanced CT may be possible, limiting the assessment. MRI abdomen may be useful in this setting, given the superior soft tissue resolution of MRI compared to unenhanced CT.

CT Abdomen and Pelvis

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There is no relevant literature with high-quality evidence regarding the use of CT of the pelvis in the staging of RCC. Although it is likely that CT pelvis may not offer additional information in most patients with early stage RCC, pelvic imaging can be helpful in patients with more advanced RCC, in whom metastatic spread is suspected [47,48]. If pelvic imaging is indicated in patients with contraindications to iodinated contrast, pelvic MRI may be preferred to unenhanced CT pelvis.

CT Chest

Chest imaging is indicated in the staging of RCC, given that lungs are one of the most common sites of metastases in RCC [5,13]. There is a lack of literature that have directly compared the accuracy of chest CT with chest radiography for detecting pulmonary metastases in the initial staging of RCC. However, limited data have demonstrated that CT is more sensitive than radiography for the detection of pulmonary metastases from RCC [49].

Current literature supports use of IV contrast-enhanced CT chest for detecting pulmonary metastases, especially in patients with large renal tumors [5,13,34,63,64,74,75]. However, in patients with contraindications to iodinated contrast, unenhanced CT chest may be performed because that would be able to detect pulmonary nodules, despite the lack of IV contrast.

CT Head
Most patients with metastases to the central nervous system are symptomatic. Thus, current guidelines do not support routine imaging of the brain to search for metastases in asymptomatic patients in the initial staging of RCC. Brain imaging should be performed only in cases with suggestive signs or symptoms [5,13]. In patients with contraindication to IV contrast, MRI brain may be more helpful.

CTU
There is no relevant literature suggesting that CTU offers any additional benefit over conventional CT of the abdomen in the initial staging of RCC, and thus, this method is not included in the guidelines from the EAU and NCCN [5,13].

FDG-PET/CT Skull Base to Mid-Thigh
FDG-PET/CT has a limited role in the diagnosis and the local staging of RCC [58]. Differentiating renal tumor from background normal renal tissue can be difficult because of renal excretion of FDG. Furthermore, RCC is reported to have variable FDG avidity, limiting its utility. Nakanishi et al [59] reported a 56% sensitivity, a 67% specificity, a 15% positive predictive value, a 57% negative predictive value, and a 65% accuracy for FDG-PET in the staging of RCC. A recent clinical trial from Turkey involving 62 patients with RCC reported an 84% accuracy for contrast-enhanced FDG-PET/CT in staging RCC [60]. However, further studies are warranted before PET/CT can be used in the routine initial staging of RCC. At present, given the paucity of literature to support the use of FDG-PET/CT, the guidelines from the EAU and NCCN do not recommend routine FDG-PET/CT in the initial staging of RCC [5,13].

Fluoride PET/CT Skull Base to Mid-Thigh
Preliminary results for other PET tracers are also becoming available. In a small prospective study of 10 patients with metastatic RCC, 18F-NaF PET/CT was found to be significantly more sensitive for the detection of RCC skeletal metastases than Tc-99m bone scintigraphy or CT, with sensitivities of 100%, 29%, and 46%, respectively. CT and Tc-99m bone scintigraphy in this study identified only 65% of the metastases detected by fluoride PET/CT [61]. However, given the paucity of litereature for utility of fluoride PET/CT in the initial staging of RCC, current guidelines from the EAU and NCCN do not support routine fluoride PET/CT to search for metastases in asymptomatic patients in the initial staging of RCC [5,13].

MRI Abdomen and Pelvis
MRI of the abdomen without and with IV contrast is considered to be a reliable method for the staging of RCC. Various MRI sequences, including T2-weighted, chemical shift T1-weighted, contrast-enhanced T1-weighted, and diffusion-weighted images, are typically obtained for the staging of RCC.

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In patients with contraindications to both iodinated CT and gadolinium-based MRI IV contrast, unenhanced MRI may be preferred over noncontrast CT. This is due to the fact that unenhanced MRI has a superior soft tissue resolution compared to unenhanced CT, thereby increasing its diagnostic utility.

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US Abdomen
US can be useful in the characterization of renal masses as it can help in differentiating solid and cystic renal masses. However, it is seldom used in the staging of RCC because of its relatively poor performance in evaluating local tumor spread and metastatic disease [70,71]. Additional challenges in the use of US may be related to incomplete visualization of the mass, acoustic shadowing from partially calcified cysts or masses, variability in echogenicity of hemorrhagic cysts, and poor sensitivity in diagnosing isoechoic small renal tumors. There is no relevant literature suggesting that US offers any additional benefit over conventional CT or MRI of the abdomen in the initial staging of RCC, and thus, this method is not included in the guidelines [5,13]. However, intraoperative US may be helpful in performing partial nephrectomy, especially in patients with endophytic renal tumors [72,73].

Variant 3: Renal cell carcinoma. Contraindication only to iodinated CT intravenous contrast. Staging.

Bone Scan Whole Body
The prevalence of osseous metastases for localized RCC has been shown to be low in patients without symptoms (ie, bone pain) or without laboratory abnormalities suggestive of osseous metastases (ie, elevated serum alkaline phosphatase level) [11,12]. Furthermore, the sites commonly involved by osseous metastases, such as the thoracolumbar spine and ribs, are located in areas covered by chest and abdominal imaging. Thus, even though bone scanning can be helpful to confirm clinically or radiographically suspected metastatic disease, current guidelines from the EAU and NCCN do not support its routine use in the initial staging of asymptomatic RCC [5,13].

Bone Scan Whole Body with SPECT or SPECT/CT Area of Interest
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In patients with RCC with symptoms suspicious for bone metastases, bone scan may be useful. If the bone scan shows areas of abnormal radiotracer uptake suspicious for osseous metastases, SPECT fused with CT can be used to provide detailed anatomic localization of the abnormal radiotracer uptake and further improve the characterization of the nature of the abnormality [14].

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MRI Head

Most patients with metastases to the central nervous system are symptomatic. Thus, current guidelines do not support routine imaging of the brain to search for metastases in asymptomatic patients in the initial staging of RCC.

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Radiography Chest

The lung is the most common site of metastases in patients with RCC presenting with synchronous metastases. Although the incidence of metastases in RCC <4 cm is low (approximately 1%-2%), it has been reported that 20% to 30% of T1a tumors may have potentially aggressive histologic features. Hence, chest radiography is usually performed in the staging of RCC [13]. However, CT is more sensitive than radiography for the detection of pulmonary metastases from RCC during staging. In addition to a high sensitivity for the detection of pulmonary metastases, chest CT has a high sensitivity for the detection of intrathoracic nodal metastases from RCC. Therefore, in patients with higher risk of pulmonary metastases (such as tumor >4 cm, cN1, presence of systemic symptoms), chest CT is preferred [54,55].

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Summary of Recommendations

- **Variant 1**: MRI abdomen and pelvis without and with IV contrast, or MRI abdomen without and with IV contrast, or CT abdomen and pelvis with IV contrast, or CT abdomen with IV contrast is usually appropriate for staging of RCC in patients without contraindications to either iodinated CT contrast or gadolinium-based MR IV contrast. These procedures are equivalent alternatives (eg, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care) and are complemented by CT chest with IV contrast (ie, more than one procedure is ordered as a set or simultaneously in which each procedure provides unique clinical information to effectively manage the patient's care). Although the panel did not agree on recommending CT abdomen and pelvis without and with IV contrast or CT abdomen without and with IV contrast, because there is insufficient medical literature to conclude whether these patients would benefit from the procedures, their use may be appropriate.
- **Variant 2**: MRI abdomen and pelvis without and with IV contrast or MRI abdomen without and with IV contrast is usually appropriate for staging of RCC in patients with contraindications to both iodinated CT contrast or gadolinium-based MR IV contrast. These procedures are equivalent alternatives (eg, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care) and are complemented by CT chest without IV contrast (ie, more than one procedure is ordered as a set or simultaneously in which each procedure provides unique clinical information to effectively manage the patient's care). Although the panel did not agree on recommending CT abdomen without IV contrast, because there is insufficient medical literature to conclude whether these patients would benefit from the procedure, its use may be appropriate.
- **Variant 3**: MRI abdomen and pelvis without and with IV contrast or MRI abdomen without and with IV contrast is usually appropriate for staging of RCC in patients with contraindication only to iodinated CT IV contrast. These procedures are equivalent alternatives (eg, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care) and are complemented by CT chest without IV contrast (ie, more than one procedure is ordered as a set or simultaneously in which each procedure provides unique clinical information to effectively manage the patient's care).

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

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. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document [76].

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

References

1. American Cancer Society. Kidney Cancer. Available at: https://www.cancer.org/cancer/kidney-cancer.html. Accessed November 30, 2022.
2. Siegel RL, Miller KD, Fuchs HE, Jemal A. Cancer Statistics, 2021. CA Cancer J Clin 2021;71:7-33.
3. Li ZC, Zhai G, Zhang J, et al. Differentiation of clear cell and non-clear cell renal cell carcinomas by all-relevant radiomics features from multiphase CT: a VHL mutation perspective. Eur Radiol 2019;29:3996-4007.
4. Amin MB, Edge S, Greene F, et al. *AJCC Cancer Staging Manual.* 8th ed. New York, NY: Springer; 2017.
5. Ljungberg B, Albiges L, Abu-Ghanem Y, et al. European Association of Urology Guidelines on Renal Cell Carcinoma: The 2019 Update. Eur Urol 2019;75:799-810.
6. National Cancer Data Base (NCDB). Available at: http://www.facs.org/cancer/ncdb/index.html. Accessed November 30, 2022.
7. Leslie JA, Prihoda T, Thompson IM. Serendipitous renal cell carcinoma in the post-CT era: continued evidence in improved outcomes. Urol Oncol 2003;21:39-44.
8. Flanigan RC, Campbell SC, Clark JI, Picken MM. Metastatic renal cell carcinoma. Curr Treat Options Oncol 2003;4:385-90.
9. Griffin N, Gore ME, Sohaib SA. Imaging in metastatic renal cell carcinoma. AJR Am J Roentgenol 2007;189:360-70.
10. Elkassem AA, Allen BC, Sharbidre KG, Rais-Bahrami S, Smith AD. Update on the Role of Imaging in Clinical Staging and Restaging of Renal Cell Carcinoma Based on the AJCC 8th Edition, From the AJR Special Series on Cancer Staging. AJR Am J Roentgenol 2021;217:541-55.
11. Blacher E, Johnson DE, Haynie TP. Value of routine radionuclide bone scans in renal cell carcinoma. Urology 1985;26:432-4.
12. Koga S, Tsuda S, Nishikido M, et al. The diagnostic value of bone scan in patients with renal cell carcinoma. J Urol 2001;166:2126-8.
13. NCCN Clinical Practice Guidelines in Oncology. Kidney Cancer. Version 2.2022. Available at: https://www.nccn.org/professionals/physician_gls/pdf/kidney.pdf. Accessed November 30, 2022.
14. Utsunomiya D, Shiraishi S, Imuta M, et al. Added value of SPECT/CT fusion in assessing suspected bone metastasis: comparison with scintigraphy alone and nonfused scintigraphy and CT. Radiology 2006;238:264-71.
15. Hallscheidt PJ, Bock M, Riedasch G, et al. Diagnostic accuracy of staging renal cell carcinomas using multidetector-row computed tomography and magnetic resonance imaging: a prospective study with histopathologic correlation. J Comput Assist Tomogr 2004;28:333-9.
16. Walter C, Kruessell M, Gindele A, Brochhagen HG, Gossmann A, Landwehr P. Imaging of renal lesions: evaluation of fast MRI and helical CT. Br J Radiol 2003;76:696-703.
17. Dalla-Palma L, Pozzi-Mucelli R. Problematic renal masses in ultrasonography and computed tomography. Clin Imaging 1990;14:83-98.
18. Fuccio C, Ceci F, Castellucci P, et al. Restaging clear cell renal carcinoma with 18F-FDG PET/CT. Clin Nucl Med 2014;39:e320-4.

19. Hillner BE, Siegel BA, Hanna L, Duan F, Quinn B, Shields AF. 18F-fluoride PET used for treatment monitoring of systemic cancer therapy: results from the National Oncologic PET Registry. J Nucl Med 2015;56:222-8.
20. Hillner BE, Siegel BA, Hanna L, et al. Impact of (18)F-Fluoride PET on Intended Management of Patients with Cancers Other Than Prostate Cancer: Results from the National Oncologic PET Registry. J Nucl Med 2014;55:1054-61.
21. Kuhn MJ, Hammer GM, Swenson LC, Youssef HT, Gleason TJ. MRI evaluation of "solitary" brain metastases with triple-dose gadoteridol: comparison with contrast-enhanced CT and conventional-dose gadopentetate dimeglumine MRI studies in the same patients. Comput Med Imaging Graph 1994;18:391-9.
22. Martinez de Llano SR, Delgado-Bolton RC, Jimenez-Vicioso A, et al. [Meta-analysis of the diagnostic performance of 18F-FDG PET in renal cell carcinoma]. Rev Esp Med Nucl 2007;26:19-29.
23. Park JW, Jo MK, Lee HM. Significance of 18F-fluorodeoxyglucose positron-emission tomography/computed tomography for the postoperative surveillance of advanced renal cell carcinoma. BJU Int 2009;103:615-9.
24. Seute T, Leffers P, ten Velde GP, Twijnstra A. Detection of brain metastases from small cell lung cancer: consequences of changing imaging techniques (CT versus MRI). Cancer 2008;112:1827-34.
25. Steffens S, Junker K, Roos FC, et al. Small renal cell carcinomas--how dangerous are they really? Results of a large multicenter study. Eur J Cancer 2014;50:739-45.
26. Tsui KH, Shvarts O, Smith RB, Figlin RA, deKernion JB, Belldegrun A. Prognostic indicators for renal cell carcinoma: a multivariate analysis of 643 patients using the revised 1997 TNM staging criteria. J Urol 2000;163:1090-5; quiz 295.
27. Wang HY, Ding HJ, Chen JH, et al. Meta-analysis of the diagnostic performance of [18F]FDG-PET and PET/CT in renal cell carcinoma. Cancer Imaging 2012;12:464-74.
28. Ates F, Akyol I, Sildiroglu O, et al. Preoperative imaging in renal masses: does size on computed tomography correlate with actual tumor size? Int Urol Nephrol 2010;42:861-6.
29. Kurta JM, Thompson RH, Kundu S, et al. Contemporary imaging of patients with a renal mass: does size on computed tomography equal pathological size? BJU Int 2009;103:24-7.
30. Irani J, Humbert M, Lecocq B, Pires C, Lefebvre O, Dore B. Renal tumor size: comparison between computed tomography and surgical measurements. Eur Urol 2001;39:300-3.
31. Goel MC, Mohammadi Y, Sethi AS, Brown JA, Sundaram CP. Pathologic upstaging after laparoscopic radical nephrectomy. J Endourol 2008;22:2257-61.
32. Jeffery NN, Douek N, Guo DY, Patel MI. Discrepancy between radiological and pathological size of renal masses. BMC Urol 2011;11:2.
33. Catalano C, Fraioli F, Laghi A, et al. High-resolution multidetector CT in the preoperative evaluation of patients with renal cell carcinoma. AJR Am J Roentgenol 2003;180:1271-7.
34. Hallscheidt P, Wagener N, Gholipour F, et al. Multislice computed tomography in planning nephron-sparing surgery in a prospective study with 76 patients: comparison of radiological and histopathological findings in the infiltration of renal structures. J Comput Assist Tomogr 2006;30:869-74.
35. Nazim SM, Ather MH, Hafeez K, Salam B. Accuracy of multidetector CT scans in staging of renal carcinoma. Int J Surg 2011;9:86-90.
36. Sokhi HK, Mok WY, Patel U. Stage T3a renal cell carcinoma: staging accuracy of CT for sinus fat, perinephric fat or renal vein invasion. Br J Radiol 2015;88:20140504.
37. Renard AS, Nedelcu C, Paisant A, et al. Is multidetector CT-scan able to detect T3a renal tumor before surgery? Scand J Urol 2019;53:350-55.
38. Landman J, Park JY, Zhao C, et al. Preoperative Computed Tomography Assessment for Perinephric Fat Invasion: Comparison With Pathological Staging. J Comput Assist Tomogr 2017;41:702-07.
39. Sawai Y, Kinouchi T, Mano M, et al. Ipsilateral adrenal involvement from renal cell carcinoma: retrospective study of the predictive value of computed tomography. Urology 2002;59:28-31.
40. Blakely S, Bratslavsky G, Zaytoun O, Daugherty M, Landas SK, Shapiro O. Preoperative cross-sectional imaging allows for avoidance of unnecessary adrenalectomy during RCC surgery. Urol Oncol 2015;33:22 e23-22 e27.
41. Nason GJ, Aslam A, Giri SK. Predictive Ability of Preoperative CT Scan in Determining Whether the Adrenal Gland is Spared at Radical Nephrectomy. Curr Urol 2016;9:143-47.
42. Tadayoni A, Paschall AK, Malayeri AA. Assessing lymph node status in patients with kidney cancer. Transl Androl Urol 2018;7:766-73.
43. Corwin MT, Lamba R, Wilson M, McGahan JP. Renal cell carcinoma metastases to the pancreas: value of arterial phase imaging at MDCT. Acta Radiol 2013;54:349-54.

44. Jain Y, Liew S, Taylor MB, Bonington SC. Is dual-phase abdominal CT necessary for the optimal detection of metastases from renal cell carcinoma? Clin Radiol 2011;66:1055-9.
45. Ng CS, Loyer EM, Iyer RB, David CL, DuBrow RA, Charnsangavej C. Metastases to the pancreas from renal cell carcinoma: findings on three-phase contrast-enhanced helical CT. AJR Am J Roentgenol 1999;172:1555-9.
46. Raptopoulos VD, Blake SP, Weisinger K, Atkins MB, Keogan MT, Kruskal JB. Multiphase contrast-enhanced helical CT of liver metastases from renal cell carcinoma. Eur Radiol 2001;11:2504-9.
47. Fielding JR, Aliabadi N, Renshaw AA, Silverman SG. Staging of 119 patients with renal cell carcinoma: the yield and cost-effectiveness of pelvic CT. AJR Am J Roentgenol 1999;172:23-5.
48. Khaitan A, Gupta NP, Hemal AK, Dogra PN, Seth A, Aron M. Is there a need for pelvic CT scan in cases of renal cell carcinoma? Int Urol Nephrol 2002;33:13-5.
49. Canvasser NE, Stouder K, Lay AH, et al. The Usefulness of Chest X-Rays for T1a Renal Cell Carcinoma Surveillance. J Urol 2016;196:321-6.
50. Winter H, Meimarakis G, Angele MK, et al. Tumor infiltrated hilar and mediastinal lymph nodes are an independent prognostic factor for decreased survival after pulmonary metastasectomy in patients with renal cell carcinoma. J Urol 2010;184:1888-94.
51. Mano R, Vertosick E, Sankin AI, et al. Subcentimeter pulmonary nodules are not associated with disease progression in patients with renal cell carcinoma. J Urol 2015;193:776-82.
52. Thompson RH, Hill JR, Babayev Y, et al. Metastatic renal cell carcinoma risk according to tumor size. J Urol 2009;182:41-5.
53. Umbreit EC, Shimko MS, Childs MA, et al. Metastatic potential of a renal mass according to original tumour size at presentation. BJU Int 2012;109:190-4; discussion 94.
54. Larcher A, Dell'Oglio P, Fossati N, et al. When to perform preoperative chest computed tomography for renal cancer staging. BJU Int 2017;120:490-96.
55. Voss J, Drake T, Matthews H, et al. Chest computed tomography for staging renal tumours: validation and simplification of a risk prediction model from a large contemporary retrospective cohort. BJU Int 2020;125:561-67.
56. Kotecha RR, Flippot R, Nortman T, et al. Prognosis of Incidental Brain Metastases in Patients With Advanced Renal Cell Carcinoma. J Natl Compr Canc Netw 2021;19:432-38.
57. Naito S, Narisawa T, Kato T, et al. Clinical utility of head computed tomography scan during systemic therapy for metastatic renal cell carcinoma. Int J Urol 2021;28:450-56.
58. Escudier B, Porta C, Schmidinger M, et al. Renal cell carcinoma: ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up. Ann Oncol 2014;25 Suppl 3:iii49-56.
59. Nakanishi Y, Kitajima K, Yamada Y, et al. Diagnostic performance of (11)C-choline PET/CT and FDG PET/CT for staging and restaging of renal cell cancer. Ann Nucl Med 2018;32:658-68.
60. Gundogan C, Cermik TF, Erkan E, et al. Role of contrast-enhanced 18F-FDG PET/CT imaging in the diagnosis and staging of renal tumors. Nucl Med Commun 2018;39:1174-82.
61. Gerety EL, Lawrence EM, Wason J, et al. Prospective study evaluating the relative sensitivity of 18F-NaF PET/CT for detecting skeletal metastases from renal cell carcinoma in comparison to multidetector CT and 99mTc-MDP bone scintigraphy, using an adaptive trial design. Ann Oncol 2015;26:2113-8.
62. Ergen FB, Hussain HK, Caoili EM, et al. MRI for preoperative staging of renal cell carcinoma using the 1997 TNM classification: comparison with surgical and pathologic staging. AJR Am J Roentgenol 2004;182:217-25.
63. Kamel IR, Hochman MG, Keogan MT, et al. Accuracy of breath-hold magnetic resonance imaging in preoperative staging of organ-confined renal cell carcinoma. J Comput Assist Tomogr 2004;28:327-32.
64. Roy C, Sr., El Ghali S, Buy X, et al. Significance of the pseudocapsule on MRI of renal neoplasms and its potential application for local staging: a retrospective study. AJR Am J Roentgenol 2005;184:113-20.
65. Lal H, Singh P, Jain M, et al. Role of MRI in staging and surgical planning and its clinicopathological correlation in patients with renal cell carcinoma. Indian J Radiol Imaging 2019;29:277-83.
66. Hallscheidt PJ, Fink C, Haferkamp A, et al. Preoperative staging of renal cell carcinoma with inferior vena cava thrombus using multidetector CT and MRI: prospective study with histopathological correlation. J Comput Assist Tomogr 2005;29:64-8.
67. Aslam Sohaib SA, Teh J, Nargund VH, Lumley JS, Hendry WF, Reznek RH. Assessment of tumor invasion of the vena caval wall in renal cell carcinoma cases by magnetic resonance imaging. J Urol 2002;167:1271-5.

68. Zini L, Destrieux-Garnier L, Leroy X, et al. Renal vein ostium wall invasion of renal cell carcinoma with an inferior vena cava tumor thrombus: prediction by renal and vena caval vein diameters and prognostic significance. J Urol 2008;179:450-4; discussion 54.
69. Adams LC, Ralla B, Bender YY, et al. Renal cell carcinoma with venous extension: prediction of inferior vena cava wall invasion by MRI. Cancer Imaging 2018;18:17.
70. Levine E, Maklad NF, Rosenthal SJ, Lee KR, Weigel J. Comparison of computed tomography and ultrasound in abdominal staging of renal cancer. Urology 1980;16:317-22.
71. Karp W, Ekelund L, Olafsson G, Olsson A. Computed tomography, angiography and ultrasound in staging of renal carcinoma. Acta Radiol Diagn (Stockh) 1981;22:625-33.
72. Sun Y, Wang W, Zhang Q, Zhao X, Xu L, Guo H. Intraoperative ultrasound: technique and clinical experience in robotic-assisted renal partial nephrectomy for endophytic renal tumors. Int Urol Nephrol 2021;53:455-63.
73. Gunelli R, Fiori M, Salaris C, et al. The role of intraoperative ultrasound in small renal mass robotic enucleation. Arch Ital Urol Androl 2016;88:311-13.
74. Bonsib SM. The renal sinus is the principal invasive pathway: a prospective study of 100 renal cell carcinomas. Am J Surg Pathol 2004;28:1594-600.
75. Margulis V, Tamboli P, Matin SF, Meisner M, Swanson DA, Wood CG. Redefining pT3 renal cell carcinoma in the modern era: a proposal for a revision of the current TNM primary tumor classification system. Cancer 2007;109:2439-44.
76. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: https://www.acr.org/-/media/ACR/Files/Appropriateness-Criteria/RadiationDoseAssessmentIntro.pdf. Accessed November 30, 2022.

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.