Cancer Imaging (2007) 7, 84–92
DOI: 10.1102/1470-7330.2007.0009

ARTICLE

Imaging in genitourinary cancer from the urologists’ perspective

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Date accepted for publication 16 April 2007

Abstract

It is well established that advances in imaging may lead to early cancer detection, more accurate tumour staging and consequently adequate treatment, better monitoring of the disease and enhanced surveillance for recurrences after treatment. This manuscript reviews the current use of imaging in genitourinary cancer and explores the impact of imaging findings in clinical management. Additionally, an effort has been made to present the emerging imaging modalities and also their possible role in diagnosis and treatment of these cancers.

Keywords: Renal cancer; urothelial cancer; testicular cancer; computed tomography (CT); magnetic resonance imaging (MRI); positron emission tomography (PET).

Introduction

According to the American Cancer Society estimations, there will be 1.4 million new cancer cases for all sites and both sexes in the US during 2006[1]. Considering that 347,000 of these cases are estimated to be genitourinary (GU) cancers, urologists will have to diagnose and confront a quarter of all the new cancer cases. Taking into account that advances in oncology and specifically in urological oncology correlate directly with advances in imaging, it is evident that imaging has a major role in the clinical management of genitourinary cancers.

The importance of imaging is expressed by its role in early cancer detection enabling the disease to be treated in a curable way, when it is still organ-confined. Improvement in early detection also results in diagnosing smaller tumours facilitating the use of minimally invasive surgical techniques and thus reducing the mortality and morbidity associated with treating cancer. In addition, advances in imaging have led to improvements in the preoperative staging of cancer and enhanced surveillance for tumour recurrence including improvement in tumour recognition. These factors significantly impact on the ability to identify the most appropriate treatment strategy for each patient and the ability for early therapeutic manipulation, while also minimising treatment-associated morbidity.

Traditional morphologically based imaging is now being complemented by functional and molecular imaging techniques that yield information about the biology of cancer[2,3]. These techniques can improve the ability to distinguish malignant from benign lesions in early-detected tumours that are usually small and may be able to distinguish the tumour’s aggressiveness. Some detected tumours may have an indolent clinical course and therefore may not require active treatment during the patient’s lifetime.

The authors aim to review the current use of imaging in GU cancer and explore the impact of imaging findings on clinical management. Each organ has been approached separately, to give a more comprehensive description. In addition, emerging imaging modalities are presented; their possible role in the diagnosis and treatment of these cancers is also discussed.

Prostate cancer (PCa)

Detection

The test procedures used traditionally in PCa screening include digital rectal examination (DRE), prostate-specific antigen (PSA), and transrectal ultrasound (TRUS). The reference standard for these tests is...
pathologic confirmation of malignancy in tissue obtained by biopsy or surgical resection. In most studies, TRUS has a reported sensitivity of 57–68% in detecting PCa in asymptomatic men\(^4,5\). However, its positive predictive value (PPV) is lower than PSA, most possibly because TRUS has a low ability to distinguish between benign and malignant nodules. Even when cancers are detected, the size of the tumour is often under estimated by TRUS. The discomfort and cost of the procedure further limit its role in screening. Nowadays, the main role of ultrasound imaging in the detection of PCa is limited to the guidance of biopsies in order to avoid sampling errors.

To improve the ability of TRUS imaging to detect PCa, attention has been given to prostatic vascularity. The exploitation of neovascularisation associated with PCa led to the use of functional imaging of the prostate. It has been shown that increased colour Doppler signal correlates positively with both prostate tumour stage and grade, as well as with the risk of recurrence after treatment\(^6\). Also, the use of power Doppler provides some further expectations in enhancing PCa detection\(^7,8\). However, Halpern et al. proved that targeted biopsy performed on the basis of high-frequency colour or power Doppler findings will still miss a substantial number of cancers detected with sextant biopsy, thus not improving the detection rate of PCa\(^9\). In addition, the combination of gray scale and Doppler ultrasound is not sufficient to eliminate the need for systematic biopsy\(^10–12\). The sensitivity of Doppler examinations could be increased by increasing the signal-to-noise ratio of the vasculature. This led to the introduction of contrast-enhanced ultrasound of the prostate and to the use of contrast-agent-specific techniques, such as harmonic imaging\(^13,14\) and intermittent scanning\(^15,16\) which may aid in detecting isoechoic as well as transition zone CaP, where conventional Doppler imaging has a high false-negative rate\(^17\). Contrast-enhanced transrectal sonography provides statistically significant improvement in discrimination between benign and malignant biopsy sites\(^18\). The detection of more aggressive cancer foci is increased and the number of biopsy cores necessary is probably decreased\(^19\), making it currently the most promising biopsy guidance technique. In an effort to increase our ability to discriminate normal from malignant tissue, ultrasound elastography has been developed which measures the relative stiffness of tissue and differentiates it by its elastic properties. Even though some studies have been done, it is still considered experimental\(^20,21\). In the future, maybe magnetic resonance (MR)-guided biopsy may play a role in the detection of PCa, especially after previous failed TRUS-guided biopsies in high-risk patients\(^22,23\). However, more and larger studies need to be performed to determine the value of MR-guided biopsy in regular clinical practice, since the high cost and time consumption preclude its application in a large patient population.

**T-staging**

After PCa has been diagnosed, it is of great importance to stage the disease accurately (TNM). The most significant parameter is to identify those patients with organ-confined disease or limited extracapsular extension. These patients will receive treatment with curative intent, while patients with more advanced disease will require palliative systemic therapy. Staging nomograms (Partin Tables) have been established to predict organ confined PCa\(^24,25\), however there is room for improved accuracy of prediction, particularly since clinical staging in these nomograms is based only on digital rectal examination, and they cannot assist in the localisation of extracapsular extension, which is critical for optimal treatment planning. The use of TRUS for local staging of PCa is controversial and in some studies it is not significantly better than DRE\(^26–28\). Doppler studies, 3D Doppler and new contrast agents have been introduced in an attempt to increase its utility, but further research is needed\(^29\). Computed tomography (CT) scans have limited ability in accurate local staging, especially in patients with increased PSA alone\(^30,31\). Magnetic resonance imaging (MRI) of the prostate provides the most accurate information to date about the anatomy and location of a tumour within the prostate gland. It is especially valuable in the detection of a T3b tumour invading the seminal vesicles. There is, however, a wide range of reported accuracies in the literature\(^32,33\), and its routine use in the staging of all prostate cancers remains controversial. MRI technology is in a rapid and sustained phase of development, and imaging of the prostate at 3 Tesla (3 T) is now possible. 3 T magnetic resonance (MR) systems provide a high signal-to-noise ratio, less distorted diffusion-weighted images, and apparent diffusion coefficient maps of the prostate. It has been shown that phased-array pelvic body coil imaging at 3 T is comparable to endorectal coil 1.5 T imaging\(^34\). In a recent study\(^35\), the clinical value of diffusion-weighted was better than T2-weighted (T2W) imaging in detecting prostate cancer using a 3 T MR system. The high accuracy of 3 T MR imaging for local staging of prostate cancer was also demonstrated in a recent prospective study by using whole-mount-section histopathologic analysis as the standard of reference\(^36\). Accuracy, sensitivity, and specificity of local staging were 94%, 88%, and 96%, respectively. In addition, minimal capsular invasion could be detected. This effort to improve cancer visualisation has also led to dynamic contrast-enhanced prostate MRI\(^36\). Prostate cancers tend to enhance more rapidly and more intensely with intravenous gadolinium than normal prostate tissue, and it seems that the relative peak enhancement may be very accurate\(^37\). There may also be a role for this technique in the investigation of postprostatectomy patients with a rising PSA; identification of abnormal foci of enhancement in the prostate bed may indicate local recurrence and guide needle biopsy for histological confirmation.
MRI with adjunctive magnetic resonance spectroscopy (MRS) has been intensely investigated during recent years. The use of detailed anatomy images provided by MRI combined with the ability of MRS to delineate the metabolic activity of different tissues has been found to correctly define the local tumour staging, with accuracies as high as 82–88%\(^\text{[38,39]}\). Recent studies confirm this extracapsular extension detection ability of MRI and MRS and their incremental value in staging nomograms\(^\text{[41,42]}\). Initial reports also confirm a relationship between Gleason grade and the magnitude of the spectral ratio abnormality\(^\text{[43]}\). An imaging technique that could non-invasively predict tumour aggressiveness, such as MRS, has the potential to distinguish potentially life-threatening tumours from cancers that would have an indolent clinical course if not treated, and therefore may not require active treatment during the patient’s lifetime. It could also be used to monitor disease progress non-invasively. Even though MRS appears to provide important information, further research is needed to confirm its value in prostate cancer staging and treatment decision making.

**N-staging**

According to the guidelines from the European Association of Urology (EAU), lymph node assessment (N-staging) should be performed when the findings will directly influence a treatment decision\(^\text{[43]}\). This is usually the case in patients for whom potentially curative treatments are planned. The American guidelines recommend use of a nomogram for CT or MRI indications\(^\text{[44]}\). A biopsy should be performed if imaging reveals suspicious nodes, otherwise a standard lymph node dissection is recommended. The gold standard for N-staging is operative lymphadenectomy, by either open or laparoscopic techniques. For nodal disease staging, MRI and CT are currently the most commonly used non-operative modalities, although their sensitivities are known to be low\(^\text{[45,46]}\). The sensitivity of CT was only 7% in N-staging in a recent meta-analysis of more than 4000 patients\(^\text{[30]}\). The conclusion in this study was that CT may be useful in T3 or Gleason score >7 but an isolated high PSA should not be an indication for imaging. Radio-immunoscintigraphy and positron emission tomography (PET) have both been investigated in order to improve lymph node assessment, however further research is needed before they can be recommended for routine use in clinical practice. With sensitivity and specificity in the range of 60–70%, radio-immunoscintigraphy with ProstaScint seems to be influenced by non-specific binding and high blood pool activity causing a low target to background ratio\(^\text{[47–49]}\). The accuracy of \(^{18}\text{F}\)Fluorodeoxyglucose (FDG)-PET in staging of PCa was found to be quite low, basically because prostate cancer is a tumour with a relatively low metabolic rate and there is also interference from tracer accumulation in the ureters and urinary bladder\(^\text{[49–51]}\). These disadvantages seem to be overcome with the use of \(^{14}\text{C}\)choline and \(^{13}\text{C}\)acetate as tracers, and therefore measuring radiopharmaceutical pathways that are different from \(^{18}\text{F}\)-FDG\(^\text{[52–58]}\). These preliminary studies show sensitivity, specificity and accuracy to be in the range of 80–95%, but it is unclear which tracers will eventually be clinically useful in the management of prostate cancer.

A promising new technique is high-resolution MRI with magnetic nanoparticles. It is based on lymphotropic super-paramagnetic nanoparticles that are internalized by macrophages in lymph nodes after injection. This causes changes in the magnetic properties detectable by MRI. In a recent study, it correctly identified all patients with nodal metastases, and in a node-by-node analysis had a significantly higher sensitivity than conventional MRI (90.5% vs. 35.4%, \(p<0.001\)) or nomograms. In addition, it allowed the detection of small (<2 mm) and otherwise undetectable lymph node metastases\(^\text{[59]}\).

**M-staging**

For detection of metastatic lesions in bones, radionuclide scintigraphy with technetium-99 is considered the gold standard and a highly sensitive imaging technique\(^\text{[60]}\). However, this technique is not very specific and false-positives may be obtained in cases of recent bone trauma, degenerative joint disease or Paget’s disease. The likelihood of a positive bone scan if the PSA is less than 20 ng/ml is found to be less than 1%\(^\text{[61]}\). Currently, bone scans are not recommended when the PSA is below 20 ng/ml in the presence of well-, or moderately differentiated tumours\(^\text{[43]}\).

**Detection of recurrence site**

After initial treatment of PCa with a curative intent (radical prostatectomy, radiotherapy), the best way to monitor the patient is by measuring serum PSA. Detectable levels of PSA after radical prostatectomy indicate residual disease. Rising PSA values (biochemical failure) during post-treatment follow up indicate recurrent PCa. The site of recurrence may be local, systemic relapse or both, and further management depends on the location and extent of the disease. Thus, the key clinical consideration is the differentiation between local and metastatic relapse. Local recurrences are offered salvage treatment (surgery, radiotherapy), while distant recurrences are managed with hormonal therapy. Clinical nomograms based on the time of recurrence, PSA kinetics and pathohistological stage and grade of the tumour have been developed to predict the source of recurrence\(^\text{[62–64]}\).

Traditionally, DRE in combination with TRUS are being used for the evaluation of local recurrence of PCa. However, the altered anatomy of the region, the development of fibrotic tissue, the fact that 30% of
recurrent tumours may be isoechoic and that some lesions are in an anterior position or extend along the bladder wall influence the accuracy of these modalities. CT has a limited role in the detection of local recurrence particularly if the size of the recurrent tumour is less than 2 cm. Endorectal coil MRI offers the best hope for improving detection rates for local recurrences with sensitivities reported to be 95–100% in addition, MRI has the advantage of imaging the entire pelvis for assessment of the nodes. However, it still does not eliminate the need for histological confirmation if deemed necessary. In combination with MRS there might be an even better improvement in the detection of locally recurrent PCa, especially in a postradiation therapy patient. If there is absence of metabolic activity in the prostatic fossa after prostatectomy or in the prostate gland after radiotherapy, then systemic relapse is indicated.

Radionuclide bone scans and computed tomography are the most frequently used imaging modalities in the evaluation of metastatic disease. They have easy availability, relatively low cost and virtually no contraindications. In addition, CT can be used to characterise focal uptake presented in the bone scan as benign or malignant. However, CT has a quite low specificity because it discriminates metastases when the nodal size is >1 cm. Bone scans, on the other hand, are rarely positive before the PSA is above 30 ng/ml. Even though MRI is very good for evaluating bone marrow metastases, it is rarely used for this purpose because it is an expensive modality, time consuming and susceptible to motion artefacts. ProstaScint imaging, with reported sensitivity of 44–92%, specificity of 36–86% and false-negative rate of 10–20%, does not seem useful in the detection of local recurrence; however, it may have a role in the detection of nodal metastases in patients with rising PSA but negative bone scan who might otherwise be candidates for local salvage therapy. With PET scans, it is evident that choline and acetate are more efficient tracers than FDG in differentiating the site of recurrence, but they are still considered investigational. In the future, combined PET/CT could provide more accurate recurrence detection since preliminary data indicate its value.

Renal cell cancer (RCC)

With the increasingly common use of cross-sectional imaging, the majority of RCCs are nowadays diagnosed incidentally during investigation of unrelated complaints. As a result, the classic clinical triad of pain, haematuria, and palpable mass is seen less frequently than previously and there is also a continuously rising incidence of RCC. Incidentally, diagnosed RCCs are generally of smaller size and lower stage than symptomatic ones, and as such they have a better prognosis. In addition, the increasing number of T1a tumours (less than 4 cm, limited to the kidney) has generated the need for development and refinement of nephron sparing surgery (partial nephrectomy, cryoablation, radiofrequency ablation). However, the detection of incidental small renal masses poses diagnostic and therapeutic dilemmas, such as distinguishing benign from malignant lesions and deciding how to treat them. Thus, the role of any preoperative imaging in RCC is to differentiate benign from malignant lesions, to adequately assess tumour size and stage, and to reliably predict the presence and cranial extent of any thrombus of the vena cava.

The majority of asymptomatic renal tumours (up to 80%) are detected incidentally at ultrasound. The detection mainly depends on the size, location and echogenicity of the lesion. In general, the size limit that can be detected with ultrasound is considered to be 1.5 cm which provides a sensitivity of 80% for the discovery of small renal masses. However, not all cancers present with typical sonographic characteristics; the smaller the lesion, the more likely it is to be isoechoic and homogeneous. In these cases the use of colour Doppler may be helpful. The standard imaging test for the evaluation of patients with renal masses is CT. Helical CT may identify RCC with a sensitivity of 100% and specificity of 88–95%, and it can accurately predict tumour size with only a 0.5 cm difference compared to the pathological size of the lesion. Ultrasonography might contribute some additional diagnostic information over CT in the evaluation of atypical cystic lesions, solid renal tumours with poor vascularity and angiomyolipomas with a minimal fat component. Colour Doppler ultrasound (US) and helical CT can both identify the presence of a thrombus in the renal vein or vena cava. However, since the preoperative knowledge of the status of the thrombus is of great importance in order to plan the surgical approach, MRI is more reliable in identifying the cranial extent of the thrombus and also differentiates between tumour thrombus and other types. MRI produces high-resolution multiplanar images providing the precise location of the tumour and can also provide both morphological and functional information. It is now a useful supplement for characterising indeterminate renal masses that cannot be classified with CT and US, and in staging RCC. In addition, MRI may be used in patients who cannot be assessed by CT because of allergy to iodinated contrast media and in patients with renal insufficiency.

In the assessment for the existence of retroperitoneal lymph node metastases, CT has a sensitivity as high as 95%, but using a nodal size of 1 cm or greater as criterion, the rate of false-positive findings can range from 3% to 43%. This high false-positive rate is mainly caused by the presence of micrometastases and of reactive hyperplasia. Multidetector CT with thin collimation and multiplanar reformatting seems a very promising modality, which might result in a diagnostic improvement.
The identification of multifocal lesions is another issue in preoperative imaging because of the growing interest in conservative surgery. The incidence of multifocality in RCC is estimated at between 5 and 25% and is a major source of local recurrence following partial nephrectomy\(^ {94,95}\). Spiral CT scan and MRI can characterise a lesion as small as 10 mm and lower respectively, but cannot distinguish malignancy; intraoperative ultrasound has a sensitivity of only 78%\(^ {96–98}\). The evaluation of unenhanced CT scans together with enhanced corticomedullary and nephrographic phases revealed 100% sensitivity as published in one study, suggesting that this technique might be a valuable option\(^ {99,100}\).

For the evaluation of metastatic disease and local recurrence, CT shows good sensitivity and is the standard imaging test. Nuclear medicine studies with PET have a limited sensitivity for evaluating metastatic RCC and particularly for small metastatic lesions. However, a positive PET scan should be considered strongly suspicious for local recurrence or metastasis, because of the high specificity and PPV of this test. A combined test (PET/CT) may be necessary if important management decisions are to be based on the test result. This would take advantage of the high sensitivity of CT and high specificity of PET in patients with metastatic RCC\(^ {101,102}\).

One of the latest advancements in imaging in evaluation prior to nephron sparing surgery for small RCCs is volume-rendered three-dimensional CT reconstructions. The location of the kidney relative to the rib cage, iliac crest, and spine provides the surgeon with a virtual ‘road map’ for the operation\(^ {103,104}\). Tumour location, depth of extension and its relationship to the renal collecting system are well visualised on 3D images, allowing for complete tumour excision with preservation of normal surrounding renal parenchyma and minimised postoperative complications such as urinary fistulas\(^ {104}\). In addition, 3D volume rendering may supplement conventional 2D images in portraying complex renal anatomy that may have been difficult to recognize otherwise\(^ {103,105}\).

New imaging techniques applicable to MRI of the kidneys are on the horizon, but their potential role in the management of renal cancer has yet to be fully explored. MR spectroscopy (MRS) allows the chemical composition of different tissues to be determined; making this technique potentially useful for characterising renal masses or monitoring the response of renal neoplasms to different treatments\(^ {106,107}\). Arterial spin labelling (ASL) is an MRI method in which an MR image can be sensitised to the effect of inflowing blood, and perfusion to tissues can be quantified. This may prove to be a useful technique for characterising metastatic renal neoplasms and evaluating their response to treatment\(^ {108}\). Finally, diffusion-weighted MRI (DWI) is a technique that can provide non-invasive quantification of water diffusion and shows promise for assessing renal function\(^ {109,110}\) and characterising renal masses\(^ {31}\). Combined with conventional MRI, DWI allows the acquisition of morphologic and functional information, and may allow earlier depiction of alterations in disease processes, during a single examination.

### Bladder cancer

The predominant presenting symptom of bladder cancer is painless gross or microscopic haematuria. Thus, almost all patients will eventually be examined cystoscopically, making endoscopy the standard diagnostic method. Proper staging of the tumour is essential for further treatment. The first aspect that has to be assessed is whether the patient has a superficial or a muscle-invasive tumour (≤T1 vs ≥T2), since infiltration beyond the lamina propria will require more aggressive treatment than transurethral resection. The role of imaging in T-staging is not that essential. Intravenous urography is not useful for staging bladder cancer, even though some bladder tumours that cause ureteral obstruction are often muscle invasive\(^ {111,112}\). Ultrasound is also not used for staging because of its limited ability to evaluate the perivesical tissue\(^ {113,114}\). CT and MRI delineate the perivesical tissue, but staging accuracy is quite variable, ranging from 40% to 98%\(^ {115–117}\), with MRI being slightly more accurate for staging than CT\(^ {114}\). Currently, the most accurate method for differentiating T1 from T2 tumours is with a tissue specimen obtained from the muscularis propria of the tumour base during transurethral resection of the tumour (TURBT). Another determination of importance is whether the invasive tumour has penetrated through the bladder wall and to what extent, which means identifying patients with invasive tumours who may benefit from aggressive, potentially curative therapy. In the vast majority of cases, it is unlikely that this can be reliably distinguished using transurethral resection alone. Considering also that in cases of pelvic sidewall or abdominal wall infiltration (stage T4b) or metastases in pelvic lymph nodes or bone marrow, palliative chemo- or radiation therapy is given, accurate staging is very essential. When pelvic imaging is performed after TURBT, staging accuracy decreases to 32–55% because postoperative inflammation mimics the appearance of tumour infiltration\(^ {111,116–118}\). Transurethral ultrasound before and after TURBT has been reported to achieve good discrimination ability, but further studies are needed for confirmation\(^ {119}\). Ultra-fast dynamic MRI sequences may be a more reliable method for distinguishing residual tumour from postoperative inflammation\(^ {116}\). As it is rare for metastases to be associated with superficial disease, MRI and CT are used for assessing the presence of metastases in patients with documented muscle-invasive bladder cancer\(^ {116}\). However, the accuracy of MRI and CT for lymph node staging ranges from 70% to 98%, with a false-negative rate of 20–40%\(^ {114,116,117}\). Currently, the
preferred method for accurate N-staging still remains pelvic lymphadenectomy.

Promising results in improving nodal imaging were recently reported with the use of ferumoxtran-10-enhanced magnetic resonance MRI. In this study of 58 patients, sensitivity and negative predictive value improved significantly at postcontrast imaging (from 76% to 96%; \( P < 0.001 \)) compared with those at precontrast imaging (from 91% to 98%; \( P < 0.01 \)). In addition, metastasis was found prospectively in 10 of 12 normal-sized nodes (less than 10 mm).

**Upper tract urothelial cancer**

Upper tract urothelial tumours are usually diagnosed as radiolucent filling defects on excretory or retrograde urography. However, it is known that urography has limited ability in detecting small tumours of the ureter and renal pelvis, and the findings must be differentiated from non-opaque calculi, blood clots, papillary necrosis and inflammatory lesions. Thus, the detected lesions have to be further characterised by ultrasonography, contrast-enhanced CT or MRI. All of these imaging modalities have a limited role when the tumour is small, however, CT and MRI allow simultaneous examination of abdominal and retroperitoneal structures for signs of regional or distant metastases. In cases of inconclusive results, ureteropyeloscopy is performed allowing direct visualisation and biopsies to be performed. Newer imaging modalities include contrast-enhanced multidetector CT after injection with furosemide and MR urography with heavily T2-weighted pulse sequences and with T1-weighted fast gradient-echo sequence after the intravenous administration of non-nephrotoxic gadolinium. These techniques allow the evaluation of intraluminal upper tract lesions at an early stage with quite promising results. In addition, the latter technique can be used to evaluate the dilated and undilated urinary tract, even in patients with impaired renal function. In an attempt to overcome the problem of peristaltic movement of the ureters and to ensure maximum opacification of the collecting system and ureters during CT urography, various techniques have been recently been suggested (furosemide and spasmolytic medication administration, etc.) but further evidence is still needed to confirm the ideal method.

**Testicular cancer**

A primary testicular tumour can be rapidly and accurately assessed by scrotal ultrasonography. US can determine whether the mass is truly intratesticular, can differentiate tumour from epididymal pathology and facilitates testicular examination in the presence of hydrocele. Once the diagnosis of testicular cancer has been established by inguinal orchidectomy, accurate staging of the disease is mandatory in order to assess the need for appropriate postorchidectomy therapy. Routine chest x-rays detect 85–90% of pulmonary metastases; the retroperitoneum is most commonly evaluated with CT since MRI is of no additional value. However, since CT has a false negative rate of 30–59% for evaluating early stage testicular cancer and since it is unable to differentiate between residual tumour, fibrosis and teratoma, new imaging modalities have been investigated. PET has been show to be beneficial in the evaluation of residual masses after chemotherapy and particularly in differentiating viable carcinoma from scar tissue. However, it is unable to differentiate scar tissue from mature teratoma and it does not surpass CT in initial staging. Among the most recent imaging techniques in early stage testicular cancer is lymphotropic nanoparticle-enhanced magnetic resonance imaging. In the first reported study, it was able to detect metastases in nodes smaller than 10 mm and had overall 100% sensitivity and specificity. However, this was a small study (\( n = 22 \)), so a larger trial is necessary to confirm its accuracy and diagnostic utility.

**Conclusion**

Imaging studies are and will be the cornerstones of diagnosis, staging and post-treatment follow up of patients with genitourinary cancer. However, they do have considerable limitations, but the results from ongoing research indicate that we can expect significant improvements. Vascularity guided techniques are very promising as well as nanotechnology, and it is most possible that they will have a key role in the future. In addition, the role of imaging in the future may be even more beneficial for cancer patients, since the potentiality of these new advances may also lead to the treatment of these patients with image-guided therapies.

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