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ARTICLE

Imaging in genitourinary cancer from the urologists' perspective

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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

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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 probable 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[29,30]. 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[31], 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[32,33]. In a recent study[34], 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[35]. 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%[38–40]. Recent studies confirm this extracapsular extension detection ability of MRI and MRS and their incremental value in staging nomograms[41,42]. Initial reports also confirm a relationship between Gleason grade and the magnitude of the spectral ratio abnormality[2]. 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 life time. 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[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[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[45,46]. The sensitivity of CT was only 7% in N-staging in a recent meta-analysis of more than 4000 patients[30]. The conclusion in this study was that CT may be useful in T3–4 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[47–49]. The accuracy of [^{18}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[49–51]. These disadvantages seem to be overcome with the use of [^{11}C]choline and [^{11}C]acetate as tracers, and therefore measuring radiopharmaceutical pathways that are different from ^{18}F-FDG[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[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[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%[61]. Currently, bone scans are not recommended when the PSA is below 20 ng/ml in the presence of well-, or moderately differentiated tumours[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[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[65–67]. 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%[68,69]. 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[70]. 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[71]. 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[72]. 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%[73,74], 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[75]. 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[76–79].

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 RCCs[80–83]. Incidentally, diagnosed RCCs are generally of smaller size and lower stage than symptomatic ones, and as such they have a better prognosis[81,84]. 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[85]. 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[86]. 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[87,88]. 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[89]. 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[90]. 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[85]. 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%[91], 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[92]. Multidetector CT with thin collimation and multiplanar reformatting seems a very promising modality, which might result in a diagnostic improvement[93].

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[3]. 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 ($\leq$T1 vs $\geq$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[113,116–118]. 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 lympadenectomy.

Promising results in improving nodal imaging were recently reported with the use of ferumoxtran-10-enhanced magnetic resonance MRI[120]. 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[121]. 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 urography after injection with furosemide[122] 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[123]. 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[124].

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[124] and since it is unable to differentiate between residual tumour, fibrosis and teratoma, new imaging modalities have been investigated. PET has been shown 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[125]. Among the most recent imaging techniques in early stage testicular cancer is lymphotrophic nanoparticle-enhanced magnetic resonance imaging[126]. In the first reported study, it was able to detect metastases in nodes smaller than 10 mm and had overall 100% sensitivity and specificity[127]. 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.

References

[1] American Cancer Society. Cancer facts and figures; Atlanta: American Cancer Society; 2006.

[2] Catalona WJ, Richie JP, Ahmann FR, *et al.* Comparison of digital rectal examination and serum prostate specific antigen in the early detection of prostate cancer: results of a multicenter clinical trial of 6,630 men. J Urol 1994; 151: 1283–90.

[3] Babaian R, Mettlin C, Kane R, *et al.* The relationship of prostate-specific antigen to digital rectal examination and transrectal ultrasonography. Cancer 1992; 69: 1195–200.

[4] Ismail M, Petersen RO, Alexander AA, Newschaffer C, Gomella LG. Color Doppler imaging in predicting the biologic behavior of prostate cancer: correlation with disease-free survival. Urology 1997; 50: 906–12.

[5] Cho JY, Kim SH, Lee SE. Diffuse prostatic lesions: role of colour Doppler and power Doppler ultrasonography. J Ultrasound Med 1998; 17: 283–7.

[6] Okihara K, Kojima M, Naya Y, Iida A, Watanabe M, Watanabe H. Ultrasonic power Doppler imaging for prostatic cancer: a preliminary report. Tohoku J Exp Med 1997; 182: 277–81.

[7] Halpern EJ, Frauscher F, Strup SE, Nazarian LN, O'Kane P, Gomella LG. Prostate: high frequency Doppler US imaging for cancer detection. Radiology 2002; 225: 71–7.
[8] Kelly IMG, Lees WR, Rickards D. Prostate cancer and the role of colour Doppler US. Radiology 1993; 189: 153–6.
[9] Newman JS, Bree RL, Rubin JM. Prostate cancer: diagnosis with colour Doppler sonography with histologic correlation of each biopsy site. Radiology 1995; 195: 86–90.
[10] Cornud F, Belin X, Piron D, *et al.* Colour Doppler-guided prostate biopsies in 591 patients with an elevated serum PSA level: impact on Gleason score for non-palpable lesions. Urology 1997; 49: 709–15.
[11] Burns PN. Harmonic imaging with ultrasound contrast agents. Clin Radiol 1996; 51(Suppl 1): 50–5.
[12] Burns PN, Hope SD, Averkiou MA. Nonlinear imaging. Ultrasound Med Biol 2000; 26(Suppl 1): S19–22.
[13] Halpern EJ, Frauscher F, Rosenberg M, Gomella LG. Directed biopsy during contrast-enhanced sonography of the prostate. Am J Roentgenol 2002; 178: 915–19.
[14] Halpern EJ, McCue PA, Aksnes AK, Hagen EK, Frauscher F, Gomella LG. Contrast-enhanced US of the prostate with Sonazoid: comparison with whole-mount prostatectomy specimens in 12 patients. Radiology 2002; 222: 361–6.
[15] Roy C, Buy X, Lang H, Saussine C, Jacqmin D. Contrast enhanced colour Doppler endorectal sonography of prostate: efficiency for detecting peripheral zone tumors and role for biopsy procedure. J Urol 2003; 170: 69–72.
[16] Heijmink SW, van Moerkerk H, Kiemeney LA, Witjes JA, Frauscher F, Barentsz JA. Comparison of the diagnostic performance of systematic versus ultrasound-guided biopsies of prostate cancer. Eur Radiol 2006; 16: 927–38.
[17] Halpern E, Ramey R, Strup S, Frauscher F, McCue V, Gomilla L. Detection of prostate carcinoma with contrast-enhanced sonography using intermittent harmonic imaging. Cancer 2005; 104: 2373–83.
[18] Cochlin D, Ganatraand D, Griffiths F. Elastography in the detection of prostatic cancer. Clin Radiol 2002; 57: 1014–20.
[19] Konig K, Scheipers U, Pesavento A, Lorenz A, Ermert H, Senge T. Initial experiences with real-time elastography guided biopsies of the prostate. J Urol 2005; 174: 115–7.
[20] Zangos S, Eichler K, Engelmann K, *et al.* MR-guided transgluteal biopsies with an open low-field system in patients with clinically suspected prostate cancer: technique and preliminary results. Eur Radiol 2005; 15: 174–82.
[21] Beyersdorff D, Winkel A, Hamm B, Lenk S, Loening SA, Taupitz M. MR imaging-guided prostate biopsy with a closed MR unit at 1.5 T: initial results. Radiology 2005; 234: 576–81.
[22] Partin AW, Kattan MW, Subong EN, *et al.* Combination of prostate-specific antigen, clinical stage, and Gleason score to predict pathological stage of localized prostate cancer: a multi-institutional update. JAMA 1997; 277: 1445–51.
[23] Partin AW, Mangold LA, Lamm DM, Walsh PC, Epstein JI, Pearson JD. Contemporary update of prostate cancer staging nomograms (Partin Tables) for the new millennium. Urology 2001; 58: 843–8.
[24] Rifkin MD, Zerhouni EA, Gatsonis CA, *et al.* Comparison of magnetic resonance imaging and ultrasonography in staging early prostate cancer: results of a multi-institutional cooperative trial. N Engl J Med 1990; 323: 621–6.
[25] Liebross RH, Pollack A, Lankford SP, *et al.* Transrectal ultrasound for staging prostate carcinoma prior to radiation therapy: An evaluation based on disease outcome. Cancer 1999; 85: 1577–1585.
[26] Smith Jr JA, Scardino PT, Resnick MI, *et al.* Transrectal ultrasound versus digital rectal examination for the staging of carcinoma of the prostate: results of a prospective, multi-institutional trial. J Urol 1997; 157: 902–6.
[27] Purohit RS, Shinohara K, Meng MV, *et al.* Imaging clinically localized prostate cancer. Urol Clin North Am 2003; 30: 279–93.
[28] Abuzallouf S, Dayes S, Lukka H. Baseline staging of newly diagnosed prostate cancer: a summary of the literature. J Urol 2004; 171: (6 Pt 1)2122–7.
[29] Engelbrecht MR, Jager GJ, Laheij RJ, Verbeek AL, van Lier HJ, Barentsz JO. Local staging of prostate cancer using magnetic resonance imaging: a meta-analysis. Eur Radiol 2002; 12: 2294–302.
[30] Sosna J, Pedrosa I, Dewolf WC, Mahallati H, Lenkinski RE, Rofsky NM. MR imaging of the prostate at 3 Tesla: comparison of an external phased-array coil to imaging with an endorectal coil at 1.5 Tesla. Acad Radiol 2004; 11: 857–62.
[31] Kim HW, Buckley DL, Peterson DM, *et al.* In vivo prostate magnetic resonance imaging and magnetic resonance spectroscopy at 3 Tesla using a transceive pelvic phased array coil: preliminary results. Invest Radiol 2003; 38: 443–51.
[32] Miao H, Fukatsu H, Ishigaki T. Prostate cancer detection with 3-T MRI: comparison of diffusion-weighted and T2-weighted imaging. Eur J Radiol 2007; 61: 297–302.
[33] Futterer JJ, Heijmink SW, Scheenen TW, *et al.* Prostate cancer: local staging at 3-T endorectal MR imaging – early experience. Radiology 2006; 238: 184–91.
[34] Buckley DL, Roberts C, Parker GJ, Logue JP, Hutchinson CE. Prostate cancer: evaluation of vascular characteristics with dynamic contrast-enhanced T1-weighted MR imaging–initial experience. Radiology 2004; 233: 709–15.
[35] Engelbrecht MR, Huisman HJ, Laheij RJ, *et al.* Discrimination of prostate cancer from normal peripheral zone and central gland tissue by using dynamic contrast-enhanced MR imaging. Radiology 2003; 229: 248–54.
[36] Yu KK, Scheidler J, Hricak H, *et al.* Prostate cancer: prediction of extracapsular extension with endorectal MR imaging and three-dimensional proton MR spectroscopic imaging. Radiology 1999; 213: 481–8.
[37] Bartolozzi C, Crocetti L, Menchi I, Ortori S, Lencioni R. Endorectal magnetic resonance imaging in local staging of prostate carcinoma. Abdom Imaging 2001; 26: 111–22.
[38] Cornud F, Flam T, Chauveinc L, *et al.* Extraprostatic spread of clinically localized prostate cancer: factors predictive of pT3 tumor and of positive endorectal MR imaging examination results. Radiology 2002; 224: 203–10.
[39] Horiguchi A, Nakashima J, Horiguchi Y, *et al.* Prediction of extraprostatic cancer by prostate specific antigen density, endorectal MRI, and biopsy Gleason score in clinically localized prostate cancer. Prostate 2003; 56: 23–9.
[40] Wang L, Hricak H, Kattan MW, Chen HN, Scardino PT, Kuroiwa K. Prediction of organ-confined prostate cancer: incremental value of MR imaging and MR spectroscopic imaging to staging nomograms. Radiology 2006; 238: 597–603.
[41] Zakian KL, Sircar K, Hricak H, *et al.* Correlation of proton MR spectroscopic imaging with Gleason score based on step-section pathologic analysis after radical prostatectomy. Radiology 2005; 234: 804–14.
[42] Aus G, Abbou C, Bolla M, *et al.* EAU guidelines on prostate cancer. Eur Urol 2005; 48: 546–51.
[43] NCCN guidelines. Available online at: http://www.nccn.org/professionals/cms/pdf/prostate.pdf.
[44] Manyak MJ, Javitt MC. The role of computerised tomography, magnetic resonance imaging, bone scan and monoclonal antibody nuclear scan for prognosis prediction in prostate cancer. Semin Urol Oncol 1998; 16: 145–52.
[45] Rorvik J, Halvorsen OJ, Alberktsen G, Haukaas S. Lymphangiography combined with biopsy and computer tomography to detect lymph node metastases in localised prostate cancer. Scand J Urol Nephrol 1998; 32: 116–19.
[46] Harisinghani MG, Barentsz J, Hahn PF, *et al.* Noninvasive detection of clinically occult lymph-node metastases in prostate cancer. N Engl J Med 2003; 348: 2491–9.
[47] Babaian RJ, Sayer J, Podoloff DA, Steelhammer LC, Bhadkamkar VA, Gulfo JV. Radioimmunoscintigraphy of pelvic

lymph nodes with ^{111}indium-labeled monoclonal antibody CYT-356. J Urol 1994; 152: 1952–5.
[48] Lange PH. PROSTASCINT scan for staging prostate cancer. Urology 2001; 57: 402–6.
[49] Hoh CK, Seltzer MA, Franklin J, *et al.* Positron emission tomography in urological oncology. J Urol 1998; 159: 347–56.
[50] Brush JP. Positron emission tomography in urological malignancy. Curr Opin Urol 2001; 11: 175–9.
[51] Oyama N, Akino H, Suzuki Y, *et al.* Prognostic value of 2-deoxy-2-[F-18]fluoro-D-glucose positron emission tomography imaging for patients with prostate cancer. Mol Imaging Biol 2002; 4: 99–104.
[52] Fricke E, Machtens S, Hofmann M, *et al.* Positron emission tomography with ^{11}C-acetate and ^{18}F-FDG in prostate cancer patients. Eur J Nucl Med Mol Imaging 2003; 30: 607–11.
[53] DeGrado TR, Baldwin SW, Wang S, *et al.* Synthesis and evaluation of (18)F-labeled choline analogs as oncologic PET tracers. J Nucl Med 2001; 42: 1805–14.
[54] Price DT, Coleman RE, Liao RP, *et al.* Comparison of [^{18}F]fluorocholine and [^{18}F]fluorodeoxyglucose for positron emission tomography of androgen dependent and androgen independent prostate cancer. J Urol 2002; 168: 273–80.
[55] de Jong IJ, Pruim J, Elsinga PH, *et al.* Preoperative staging of pelvic lymph nodes in prostate cancer by ^{11}C-choline PET. J Nucl Med 2003; 44: 331–5.
[56] Janzen NK, Laifer-Narin S, Han KR, *et al.* Emerging technologies in uroradiologic imaging. Urol Oncol 2003; 21: 317–26.
[57] Fricke E, Machtens S, Hofmann M, *et al.* Positron emission tomography with ^{11}C-acetate and ^{18}F-FDG in prostate cancer patients. Eur J Nucl Med Mol Imaging 2003; 30: 607–11.
[58] Gerber G, Chodak GW. Assessment of value of routine bone scans in patients with newly diagnosed prostate cancer. Urology 1991; 37: 418–22.
[59] Oesterling JE. Using PSA to eliminate the staging radionuclide bone scan: significant economic implications. Urol Clin North Am 1993; 20: 705–11.
[60] De Jong IJ, Pruim J, Elsinga PH, Vaalburg W, Mensink HJ. ^{11}C-choline positron emission tomography for the evaluation after treatment of localized prostate cancer. Eur Urol 2003; 44: 32–8.
[61] Kattan MW, Wheeler TM, Scardino PT. Postoperative nomogram for disease recurrence after radical prostatectomy for prostate cancer. J Clin Oncol 1999; 17: 1499–507.
[62] D'Amico AV, Whittington R, Malkowicz SB, *et al.* The combination of preoperative prostate specific antigen and postoperative pathological findings to predict prostate specific antigen outcome in clinically localized prostate cancer. J Urol 1998; 160: 2096–101.
[63] Partin AW, Pearson JD, Landis PK, *et al.* Evaluation of serum prostate-specific antigen velocity after radical prostatectomy to distinguish local recurrence from distant metastases. Urology 1994; 43: 649–59.
[64] Saleem MD, Sanders H, Abu El Naser M, El-Galley R. Factors predicting cancer detection in biopsy of the prostatic fossa after radical prostatectomy. Urology 1998; 51: 283–6.
[65] Leventis AK, Shariat SF, Slawin KM. Local recurrence after radical prostatectomy. Correlation of US features with prostatic fossa biopsy findings. Radiology 2001; 219: 432–9.
[66] Parra RO, Wolf RM, Huben RP. The use of transrectal ultrasound in the detection and evaluation of local pelvic recurrences after a radical urological pelvic operation. J Urol 1999; 144: 707–9.
[67] Silverman JM, Krebs TL. MR imaging evaluation with transrectal surface coil of local recurrence of prostatic cancer in men who have undergone radical prostatectomy. Am J Roentgenol 1997; 168: 379–85.
[68] Sella T, Schwartz LH, Swindle P, *et al.* Endorectal coil MR in patients with PSA failure following radical prostatectomy. Radiology. 2002; 225(suppl): 351E(abstract), .
[69] Carey B. Imaging in prostate cancer. Clin Oncol 2005; 17: 553–9.
[70] Van der Wall H. The evaluation of malignancy: metastatic bone disease. In: Nuclear medicine in clinical diagnosis and treatment, 2nd edn. Murray IPC, Ell PJ, eds. . ; Edinburgh: Churchill Livingstone; 1998, p. 1169–84.
[71] Cher ML, Bianco Jr FJ, Lam JS, *et al.* Limited role of radionuclide bone scintigraphy in patients with prostate specific antigen elevations after radical prostatectomy. J Urol 1998; 160: 1387–91.
[72] Elgamal AA, Troychak MJ, Murphy GP. ProstaScint scan may enhance identification of prostate cancer recurrences after prostatectomy, radiation, or hormone therapy: analysis of 136 scans of 100 patients. Prostate 1998; 37: 261–9.
[73] Smith-Jones PM, Vallabhajosula S, Navarro V, *et al.* Radiolabeled monoclonal antibodies specific to the extracellular domain of prostate-specific membrane antigen: preclinical studies in nude mice bearing LNCaP human prostate tumor. J Nucl Med 2003; 44: 610–17.
[74] Hricak H, Schöder H, Pucar D, *et al.* Advances in imaging in the postoperative patient with a rising prostate-specific antigen level. Semin Oncol 2003; 30: 616–34.
[75] Schöder H, Larson SM. Positron emission tomography for prostate, bladder, and renal cancer. Semin Nucl Med 2004; 34: 274–92.
[76] Matthies A, Ezziddin S, Ulrich EM, *et al.* Imaging of prostate cancer metastases with (18)F-fluoroacetate using PET/CT. Eur J Nucl Med Mol Imaging 2004; 31: 797.
[77] Even-Sapir E, Metser U, Flusser G, *et al.* Assessment of malignant skeletal disease: initial experience with ^{18}F-fluoride PET/CT and comparison between ^{18}F-fluoride PET and ^{18}F-fluoride PET/CT. J Nucl Med 2004; 45: 272–8.
[78] Schmid DT, John H, Zweifel R, *et al.* Fluorocholine PET/CT in patients with prostate cancer: Initial experience. Radiology 2005; 235: 623–8.
[79] Lightfoot N, Conlon M, Kreiger N, *et al.* Impact of noninvasive imaging on increased incidental detection of renal cell carcinoma. Eur Urol 2000; 37: 521–7.
[80] Luciani LG, Cestari R, Tallarigo C. Incidental renal cell carcinoma-age and stage characterization and clinical implications study of 1092 patients (1982–1997). Urology 2000; 56: 58–62.
[81] Chow WH, Devesa SS, Warren JL, Fraumeni JF. Rising incidence of renal cell cancer in the United States. JAMA 1999; 281: 1628–31.
[82] Kim HL, Belldegrun AS, Freitas DG, *et al.* Paraneoplastic signs and symptoms of renal cell carcinoma implications for prognosis. J Urol 2003; 170: 1742–6.
[83] Lee CT, Katz J, Fearn PA, *et al.* Mode of presentation of renal cell carcinoma provides prognostic information. Urol Oncol 2002; 7: 135–40.
[84] Roy C, Buy X, el Ghali S. Imaging in renal cell cancer. EAU Update Series 2003; 1: 209–14.
[85] Isreal GM, Bosniak MA. Renal imaging for diagnosis and staging of renal cell carcinoma. Urol Clin North Am 2003; 30: 499–514.
[86] Schreyer HH, Uggowitzer MM, Ruppert-Kohlmayr A. Helical CT of the urinary organs. Eur Radiol 2002; 12: 575–91.
[87] Tann M, Sopov V, Croitoru S, *et al.* How accurate is helical CT volumetric assessment in renal tumors? Eur Radiol 2001; 11: 1435–8.
[88] Helenon O, Correas JM, Balleyguier C, Ghouadni M, Cornud F. Ultrasound of renal tumors. Eur Radiol 2001; 11: 1890–901.
[89] Hallscheidt P, Pomer S, Roeren T, Kauffmann GW, Staehler G. Preoperative staging of renal cell carcinoma with caval thrombus: is staging in MRI justified? Prospective histopathological correlated study. Urologe A 2000; 39: 36–40.
[90] Hilton S. Imaging of renal cell carcinoma. Semin Oncol 2000; 27: 150–9.

[91] Studer UE, Scherz S, Scheidegger J, *et al.* Enlargement of regional lymph nodes in renal cell carcinoma is often not due to metastases. J Urol 1990; 144: 2 Pt 1243–5.
[92] Catalano C, Fraiol Fi, 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.
[93] Karayiannis A, Varkarakis I, Chort M, Alivizatos G, Fragiskos S. Multifocality of renal cell tumors is a factor to consider before performing a partial nephrectomy. Anticancer Res 2002; 22: 3103–7.
[94] Schlichter A, Schubert R, Werner W, Zermann DH, Schubert J. How accurate is diagnostic imaging in determination of size and multifocality of renal cell carcinoma as a prerequisite for nephron-sparing surgery? Urol Int 2000; 64: 192–7.
[95] Silverman SG, Lee BY, Seltzer SE, Bloom DA, Corless CL, Adams DF. Small (<OR = 3 cm) renal masses: correlation of spiral CT features and pathologic findings. Am J Roentgenol 1994; 163: 597–605.
[96] Dockery WD, Stolpen AH. State-of-the-art magnetic resonance imaging of the kidneys and upper urinary tract. J Endourol 1999; 13: 417–23.
[97] Campbell SC, Fichtner J, Novick AC, *et al.* Intraoperative evaluation of renal cell carcinoma: a prospective study of the role of ultrasonography and histopathological frozen sections. J Urol 1996; 155: 1191–5.
[98] Kopka L, Fischer U, Zoeller G, Schmidt C, Ringert RH, Grabbe E. Dual-phase helical CT of the kidney: value of the corticomedullary and nephrographic phase for evaluation of renal lesions and preoperative staging of renal cell carcinoma. AJR Am J Roentgenol 1997; 169: 1573–8.
[99] Heidenreich A, Ravery V. Preoperative imaging in renal cell cancer. World J Urol 2004; 22: 307–15.
[100] Kang DE, White Jr RL, Zuger JH, *et al.* Clinical use of fluorodeoxyglucose F 18 positron emission tomography for detection of renal cell carcinoma. J Urol 2004; 171: 1806–9.
[101] Schöder H, Larson S. Positron emission tomography for prostate, bladder, and renal cancer. Semin Nucl Med 2004; 34: 274–92.
[102] Coll DM, Uzzo RG, Herts BR, *et al.* Three-dimensional volume rendered computerized tomography for preoperative evaluation and intraoperative treatment of patients undergoing nephron sparing surgery. J Urol 1999; 161: 1097–102.
[103] Coll DM, Herts BR, Davros WJ, *et al.* Preoperative use of 3D volume rendering to demonstrate renal tumors and renal anatomy. Radiographics 2000; 20: 431–8.
[104] Smith PA, Marshall FF, Urban BA, *et al.* Three-dimensional CT stereoscopic visualization of renal masses: impact on diagnosis and patient treatment. AJR Am J Roentgenol 1997; 169: 1331–4.
[105] Tosi MR, Rodrigues-Estrada MR, Lercker G, *et al.* Magnetic resonance spectroscopy and chromatographic methods identify altered lipid composition in human renal neoplasms. Int J Mol Med 2004; 14: 93–100.
[106] Katz-Brull R, Rofsky NM, Lenkinski RE. Breathhold abdominal and thoracic proton MR spectroscopy at 3T. Magn Reson Med 2003; 50: 461–7.
[107] De Bazelaire C, Rofsky NM, Duhamel G, Michaelson MD, George D, Alsop DC. Arterial spin labeling blood flow magnetic resonance imaging for the characterization of metastatic renal cell carcinoma. Acad Radiol 2005; 12: 347–57.
[108] Thoeny HC, De Keyzer F, Oyen RH, Peeters RR. Diffusion-weighted MR imaging of kidneys in healthy volunteers and patients with parenchymal diseases: initial experience. Radiology 2005; 235: 911–17.
[109] Namimoto T, Yamashita Y, Mitsuzaki K, Nakayama Y, Tang Y, Takahashi M. Measurement of the apparent diffusion coefficient in diffuse renal disease by diffusion weighted echo-planar MR imaging. J Magn Reson Imaging 1999; 9: 832–7.
[110] Cova M, Squillaci E, Stacul F, *et al.* Diffusion-weighted MRI in the evaluation of renal lesions: preliminary results. Br J Radiol 2004; 77: 851–7.
[111] Goessl C, Knispel HH, Miller K, *et al.* Is routine excretory urography necessary at first diagnosis of bladder cancer? J Urol 1997; 157: 480–1.
[112] Hatch TR, Barry JM. The value of excretory urography in staging of bladder cancer [abstract]. J Urol 1986; 135: 49.
[113] Lantz EJ, Hattery RR. Diagnostic imaging of urothelial cancer. Urol Clin North Am 1984; 11: 567–583.
[114] Barentsz JO, Engelbrecht MRW, Witjes JMO, de la Rosette JJMCH, van der Graaf M. MR imaging of the male pelvis. Eur Radiol. 1999; 9: 1722–36.
[115] Voges GE, Tauschke E, Stockle M, *et al.* Computerized tomography: an unreliable method for accurate staging of bladder tumors in patients who are candidates for radical cystectomy. J Urol 1989; 142: 972–4.
[116] Paik ML, Scolieri MJ, Brown SL, *et al.* Limitations of computerized tomography in staging invasive bladder cancer before radical cystectomy. J Urol 2000; 163: 1693–6.
[117] Nurmi M, Katevuo K, Puntala P. Reliability of CT in preoperative evaluation of bladder carcinoma. Scand J Urol Nephrol 1988; 22: 125–8.
[118] Barentsz JO, Jager GJ, van Vierzen PB, *et al.* Staging urinary bladder cancer after transurethral biopsy: value of fast dynamic contrast-enhanced MR imaging. Radiology 1998; 201: 185–93.
[119] Koraitim M, Kamal B, Metwalli N, Zaky Y. Transurethral ultrasonographic assessment of bladder carcinoma: its value and limitation. J Urol 1995; 154: 2 Pt 1375–8.
[120] Deserno WM, Harisinghani MG, Taupitz M, *et al.* Urinary bladder cancer: preoperative nodal staging with ferumoxtran 10-enhanced MR imaging. Radiology 2004; 233: 449–56.
[121] Grossfeld GD, Litwin MS, Wolf Jr JS, *et al.* Evaluation of asymptomatic microscopic hematuria in adults: the American Urological Association best practice policy – part II. patient evaluation, cytology, voided markers, imaging, cystoscopy, nephrology evaluation, and follow-up. Urology 2001; 89: 604–10.
[122] Nolte-Ernsting CC, Wildberger JE, Borchers H, *et al.* Multi-slice CT urography after diuretic injection: initial results. Rofo Fortschr Geb Rontgenstr Neuen Bildgeb Verfahr 2001; 89: 176–80.
[123] Nolte-Ernsting CC, Adam GB, Gunther RW. MR urography. Examination techniques and clinical applications. Eur Radiol 2001; 89: 355–72.
[124] Sanyal R, Deshmukh A, Singh Sheorain V, Taori K. CT urography: a comparison of strategies for upper urinary tract opacification. Eur Radiol 2007; 17: 1262–6.
[125] Fernandez EB, Moul JW, Foley JP, *et al.* Retroperitoneal imaging with third and fourth generation computed axial tomography in clinical stage 1 nonseminomatous germ cell tumors. Urology 1994; 44: 548–52.
[126] Janzen K, Narin S, Han K, *et al.* Emerging technologies in uroradiologic imaging. Urol Oncol 2003; 21: 317–26.
[127] Harisinghani M, Saksena M, Ross R, *et al.* A pilot study of lymphotrophic nanoparticle-enhanced magnetic resonance imaging technique in early stage testicular cancer: a new method for noninvasive lymph node evaluation. Urology 2005; 66: 1066–71.