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UROONCOLOGY

Mini Review

Biparametric magnetic resonance imaging in the surveillance of testicular tumors following radical orchiectomy

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ABSTRACT

Computed tomography has been considered the preferred imaging modality for the surveillance of patients with testicular tumors (TTs) following radical orchiectomy. However, because of the concerns of frequent radiation exposure and intravenous iodinated contrast, biparametric magnetic resonance imaging (bpMRI) is a valid and safer alternative in the surveillance of patients with TT, instead of multiparametric magnetic resonance imaging. In this review article, we propose a protocol algorithm that utilizes bpMRI in the evaluation of patients after radical orchiectomy for TTs.

Keywords: Biparametric magnetic resonance imaging; magnetic resonance imaging; radical orchiectomy; testicular cancer; whole-body magnetic resonance imaging.

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Introduction

Testicular tumors (TTs) are the most common nonhematologic cancer in men between the ages of 15 and 50 years. They account for 1% of the malignant tumors in 90%–95% of TTs. The most common TTs are the germ cell tumors (GCTs). These comprise seminomatous GCTs (SGCT), nonseminomatous GCTs (NSGCTs), and mixed GCTs. SGCTs occur in men between the ages of 35 and 45 years, whereas NSGCTs occur in men between the ages of 15 and 35 years.

Approximately 70%–80% and 20% of patients with SGCT and NSGCT, respectively, are identified at stage I.[1,2] Radical orchiectomy is the preferred treatment for a disease at stage I in almost 70%–75% of NSGCT and 83% of SGCT cases. These patients are monitored frequently by physical examination, serological testing, and cross-sectional imaging every 3–6 months for the first year and then twice in the subsequent year.[3] The remission rate for patients in the early stages is 99%, but the remission rate for the advanced stages with good, intermediate, and poor prognoses is 90%, 75–80%, and 50%, respectively.[4] TTs can metastasize via the lymphatic drainage. The retroperitoneal lymph nodes (RPLNs) are the most common sites for metastasis.[5-7] NSGCTs most frequently metastasize by hematogenous spread to the lungs.

The follow-up imaging includes an abdominal computed tomography (CT) scan[8] after orchiectomy. The chest CT is also recommended for patients with a higher risk for thoracic involvement.[3,8] According to the appropriateness criteria from the American College of Radiology, CT of the abdomen and pelvis is highly recommended for the assessment of RPLNs.[9] In young men, radiation exposure and the use of intravenous (IV) iodinated contrast is a growing concern. As a result, follow-up imaging must be planned carefully by keeping the radiation doses "as low as reasonably achievable." In addition, the CT protocol with a split bolus has been proposed to reduce the radiation dose.[10-12]

Multiparametric (mp) whole-body (WB) magnetic resonance imaging (MRI) is a valid alternative to CT scan in the staging and sur-

veillance of oncological patients. However, according to the recommendations of the European medicine agency's pharmacovigilance risk assessment committee, a suspension of 4 linear gadolinium-based contrast agents for IV injection has demonstrated the evidence of brain deposition.[13]

Biparametric MRI (bpMRI), which includes T1- and T2-weighted morphological sequences and diffusion-weighted imaging (DWI), is a valid alternative to CT and mpMRI because of the lack of radiation exposure and absence of gadolinium; yet, it provides an excellent problem-solving capability and soft-tissue characterization modality. Currently, it is used in oncology for tumor detection and staging.[14-17]

We propose the use of bpMRI in the surveillance of patients after radical orchiectomy for TTs as a safer alternative to CT.

Computed tomography

In the follow-up of patients with TTs, CT of the abdomen and pelvis is the preferred imaging modality for the staging for RPLNs because it allows an accurate assessment of the LN size and attenuation.[18] The accuracy of CT in detecting the metastatic RPLNs ranges from 73% to 97%, whereas the sensitivity and specificity can vary greatly from 65% to 96% and 81% to 100% respectively.[19-25] Frequent CT scans play a critical role in the surveillance of stage I GCT.[26] Although the data available for young men are controversial, the increasing risk of radiation exposure and cumulative dose should be taken into consideration.[27,28] Minimal benefit has been demonstrated if the patients have 5 chest/abdomen/pelvis monitoring scans at 3, 6, 9, 12, and 24 months after orchiectomy versus 2 CT scans at 3 and 12 months.[29,30]

Main Points:

- Computed tomography (CT) is the primary imaging modality for the surveillance of testicular tumors (TTs) after orchiectomy for both staging lymph nodes (LNs) and assessing for metastasis.
- Adverse reactions to iodinated contrast and the effects of radiation exposure should be considered in the surveillance of TT after orchiectomy by CT.
- Biparametric magnetic resonance imaging (bpMRI), which includes a T1- and T2-weighted morphological sequences and diffusion-weighted imaging, is a valid alternative to CT and multiparametric MRI because of the lack of radiation exposure and absence of gadolinium.
- bpMRI is accurate, with high sensitivity and specificity for detecting retroperitoneal LN in low-risk stage I seminomatous and nonseminomatous tumors.
- Whole-body-bpMRI and chest CT allow an accurate detection of LN and lung metastasis in high-risk stage II and higher nonseminomatous tumors.

Although CT is more sensitive for detecting recurrent disease in the chest[31,32], recent studies indicate that chest radiography is sufficient for follow-up for stage I seminoma[31,33-35] and stage I nonseminoma.[31,34] In patients with stage II or higher of nonseminomatous tumors, chest CT is the preferred imaging modality, with no added value for routine chest radiographs.[33,36,37]

Positron emission tomography

Positron emission tomography with 2-deoxy-2-[fluorine-18] fluoro-D-glucose integrated with computed tomography (^{18}F-FDG PET/CT) is superior to CT in detecting residual tumor in patients after chemotherapy with seminoma.[38-43] Therefore, it can be helpful for follow-up in patients with stage IIB, IIC, and III seminoma who have a mass greater than 3 cm but have normal tumor markers. However, in patients with nonseminoma, the value of FDG-PET is limited.[31,44-46]

There are both false-negative and false-positive results in patients with seminoma. The false-negative results are transitory suppression of tumor cell activity, and lesions <10 mm are difficult to detect because of the low spatial resolution on F-FDG PET/CT. However, in patients with nonseminoma, false negative results can occur because the characterization of residual masses is difficult. The false-positive results are primarily because of the inflammatory or granulomatous tissues.[47] Furthermore, in a recent trial by the National Cancer Research Institute's Testis Cancer Clinical Studies Group, when FDG-PET/CT was used

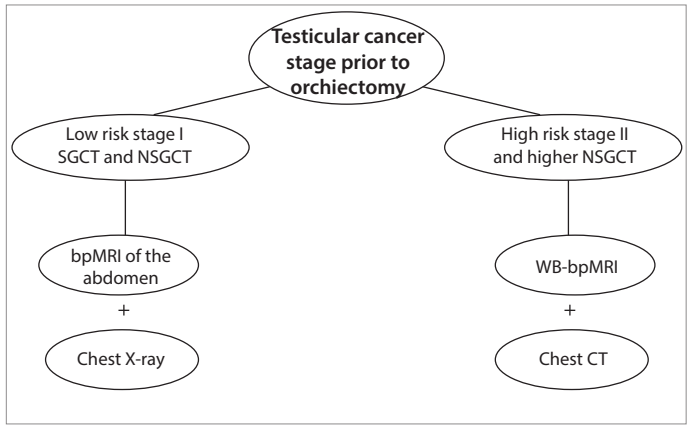

Figure 1. Our proposed algorithm for surveillance of patients with testicular cancer after orchiectomy

Abdominal biparametric magnetic resonance imaging (bpMRI) is preferred and chest X-ray is sufficient for patients with a low risk of metastasis for localizing retroperitoneal lymph nodes (RPLNs). For patients with a high risk of metastatic disease, both whole-body-bpMRI (WB-bpMRI) and chest CT are recommended. The objective is an accurate assessment of patients who have RPLNs, supradiaphragmatic lymph node (SDLNs), and lung metastasis. SGCT: seminomatous germ cell tumor; NSGCT: nonseminomatous GCT; Gd-DTPA: gadolinium-diethylenetriamine pentaacetic acid

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to predict relapse in patients with high-risk stage I NSGCT, the study was terminated early because of unacceptable relapse rates in patients with PET-negative results.[48]

Magnetic resonance imaging

In initial studies, MRI of the abdomen and pelvis without contrast was recommended in patients with a contraindication to gadolinium and in association with chest CT. The frequency of these 2 examinations is the same as that for the chest/abdomen/pelvis scans.[29,30] However, MRI is not always available, requires longer scan times, is more expensive, and has greater risks associated with gadolinium. bpMRI (morphologic T2-weighted and DWI) is a useful tool to detect the LNs for surveillance of patients with TTs. In our experience, DWI/apparent dif-

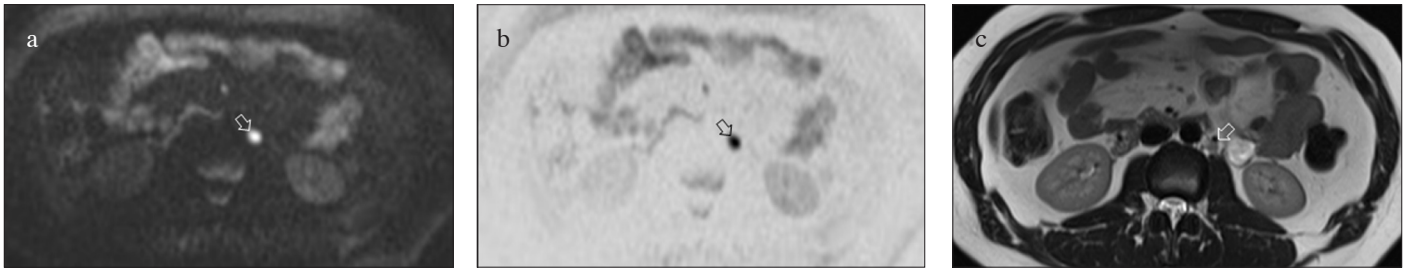

Figure 2. a-c. Abdominal biparametric 3T magnetic resonance imaging after orchiectomy for patients with seminoma shows high sensitivity of diffusion-weighted imaging (DWI) with high b-values (a) and DWI with high b-values inverted (b) in the detection and measurement of enlarged retroperitoneal lymph node (arrow in a and b) that is localized on T2-weighted imaging (arrow in c)

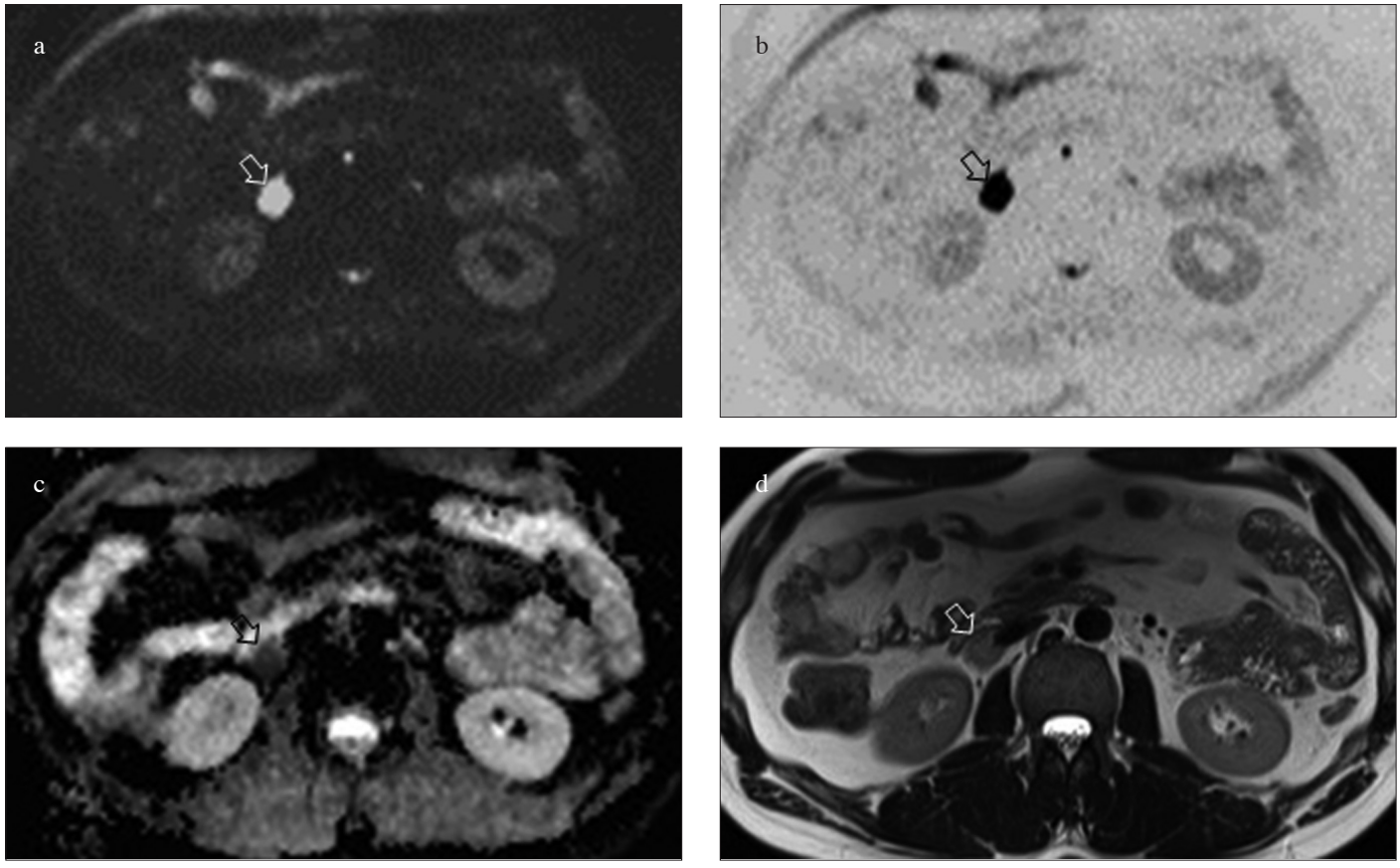

Figure 3. a-d. Abdominal biparametric 3T magnetic resonance imaging in a 26-year-old man with seminoma after radical orchiectomy. Enlarged right retroperitoneal lymph node is detected on diffusion-weighted imaging (DWI) with high b-values (arrow in a), DWI with high b-values inverted (arrow in b), diffusion apparent coefficient map (arrow in c) and localized on T2-weighted imaging (arrow and head arrow in d)

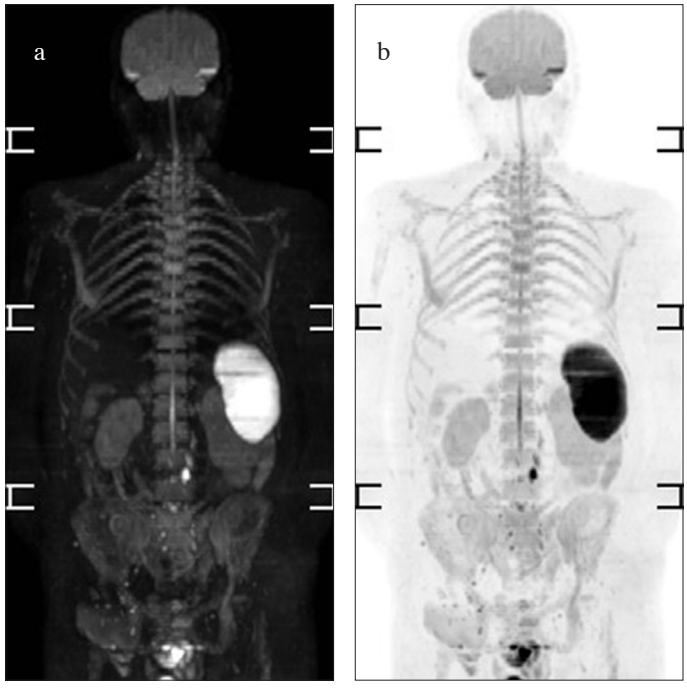

Figure 4. a, b. Whole-body biparametric magnetic resonance imaging at 1.5T in a 33-year-old man after orchiectomy for nonseminomatous germ cell tumor. Enlarged left retroperitoneal lymph node is detected on diffusion-weighted imaging (DWI) with high b-values (a) and DWI with high b-values inverted (b). Unenhanced chest computed tomography is performed to detect lung nodules

fusion coefficient (ADC), depending on the degree of restricted diffusion, bpMRI has high sensitivity in the detection of LNs; however, there are significant overlaps between the benign and malignant LNs.[18] In a study that compared MRI with CT for detection of retroperitoneal metastasis in GCT, the sensitivity varied greatly between 78% and 96%.[49]

MRI is a safer alternative to CT[49,50]; the major limitation of WB-MRI is that lung metastasis can go undetected. In this subset of patients, chest CT is recommended after the WB-MRI in patients with higher suspicion for lung metastases.[26,51]

Protocol algorithm including bpMRI for testicular tumors after orchiectomy

In Figure 1, our algorithm for patients with testicular cancer after radical orchiectomy to assess for RPLN, supradiaphragmatic LNs (SDLNs), and lung metastasis is presented. At our institution, patients who are older than 18 years with a confirmed diagnosis and no contraindication to MRI underwent 1.5T or 3T bpMRI. The MRI sequences included in the protocol, are axial T2-weighted turbo spin-echo sequences, axial gradient-echo T1-weighted Dixon (in phase, opposed phase, water, and fat), and a free breathing DWI with b-values=0, 500, and 1,000 s/mm^2 with ADC reconstruction maps. This is performed in 3–12 months after radical orchiectomy. Abdominal bpMRI is preferred for patients with a low risk of metastasis for identifying the RPLNs. For patients with a high risk of metastatic disease (stage II and NSGCT), both WB-bpMRI and chest CT are performed. The goal of imaging is to accurately identify the patients with RPLNs, SDLNs, and lung metastasis.

Based on the response evaluation criteria in solid tumors (RECIST) 1.1,[18] round or oval LNs with a short-axis diameter larger than 10 mm, loss of the normal oblong kidney bean shape, fatty hilum, or an irregular outline are considered pathologic.[52] The LNs are divided into supradiaphragmatic, retroperitoneal, and inguinal regions.

On the abdominal or WB-bpMRI, DWI with high b-values is highly sensitive in the detection and measurement of LNs, while T2-weighted imaging is highly sensitive in their localization (Figures 2-4).

Conclusion

In the follow-up of patients with TTs after radical orchiectomy, bpMRI can provide a safer alternative to abdominal CT for surveillance of the patients, thus eliminating exposure to ionizing radiation and intravenous iodinated contrast. It can also accurately detect both RPLN and SDLN with DWI and T2-weighted imaging. In patients with NSGCT with a higher risk of pulmonary metastasis, both WB-bpMRI and chest CT scan are recommended.

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