Dynamic contrast-enhanced subtraction MR imaging in assessing enhancement patterns of intratesticular mass lesions

Poster No.: C-0825
Congress: ECR 2013
Type: Scientific Exhibit
Authors: A. Tsili, A. Ntorkou, A. Ntoulia, A. Silakos, N. Sofikitis, M. Argyropoulou; Ioannina/GR
Keywords: Neoplasia, Contrast agent-intravenous, MR, Genital / Reproductive system male
DOI: 10.1594/ecr2013/C-0825

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Purpose

MR imaging of the scrotum has been reported as an important alternative modality in imaging evaluation of scrotal diseases [1-14]. The advantages of the technique include a wide field of view and multiplanar capabilities, allowing simultaneous imaging of both testicles and inguinal regions, adequate anatomic information and superiority in tissue characterization. Although sonography remains the first line modality in the investigation of scrotal pathology, due to its high sensitivity, low cost and wide availability, sonographic features may be inconclusive or inconsistent with clinical findings [5, 6]. In these patients, MR imaging examination may serve as a valuable problem-solving tool for the morphologic evaluation and tissue characterization of scrotal diseases. The technique may accurately differentiate between intratesticular and extratesticular masses, helping the characterization of the nature of scrotal lesions in many cases [1-14].

Although the majority of solid intratesticular masses should be considered malignant, it is important to recognize benign intratesticular mass lesions, for which radical orchiectomy is unnecessary. A possible diagnosis of benignity, based on imaging findings may substantially improve patient care, by reducing the number of radical surgical explorations [1-7].

Angiogenesis is considered an essential step in the pathophysiology of tumor growth [15]. Dynamic contrast-enhanced (DCE) MR imaging has emerged as a functional method for the initial diagnosis of malignancies, by assessing tumor angiogenesis [15-21]. During DCE MR imaging, carcinomas typically show rapid and intense enhancement, followed by a relatively rapid wash-out of the contrast medium. The technique has been reported useful in differentiating and characterizing breast and musculoskeletal lesions, and also in staging gynecologic malignancies, bladder and prostate carcinoma [15-21].

MR imaging of the scrotum, including a dynamic contrast-enhanced subtracted technique may provide valuable information about testicular blood flow [22-30]. There are a few published series regarding the usefulness of DCE MR imaging in the characterization of scrotal diseases [22, 25]. Reinges et al in a preliminary study reported a significantly higher maximum increase of signal intensity after gadolinium administration for testicular malignancies, when compared to normal testicular parenchyma and benign intratesticular entities [25]. Watanabe et al described the differences of the enhancement patterns in a variety of scrotal diseases, concluding that the relative percentages of peak height and mean slope, on the basis of time-signal intensity curves may be used to differentiate intratesticular from extratesticular diseases [22].

In the present study, the enhancement patterns of various intratesticular mass lesions at dynamic contrast-enhanced subtraction MR imaging were analyzed, and the value of the technique in differentiating benign from malignant testicular lesions was assessed. The patterns and the progression of contrast enhancement, in terms of time-signal intensity
plots were evaluated and calculation of the relative percentages of peak height, maximum
time and mean slope was performed.
Methods and Materials

Study patients:

This was a retrospective study of a consecutive series of 44 men (mean age: 40 years; age range: 19-75 years), referred to the Urology department for a variety of clinical symptoms (painless scrotal enlargement and/or clinically and sonographically detected scrotal mass, n=26, in two cases following a recent trauma and a testicular biopsy, respectively; scrotal pain and clinically/or sonographically detected scrotal mass, n=3; signs of epididymo-orchitis, n=6, vague scrotal pain, n=4; raised levels of a-fetoprotein, and normal sonographic examination of the scrotum, n=2; and follow-up examination of the scrotum, n=2, in one patient with a history of resected retroperitoneal extragonadal germ cell tumor, and in another case after surgical excision of a large intrascrotal hematoma). Due to the retrospective nature of the study, the institutional review board did not require approval or patients' informed consent.

The final diagnoses were 11 benign intratesticular lesions and 16 intratesticular carcinomas (Table 1).

Table 1 : Diagnoses of intratesticular mass lesions

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benign</strong></td>
<td></td>
</tr>
<tr>
<td>-acute epididymo-orchitis</td>
<td>4</td>
</tr>
<tr>
<td>-post-biopsy changes</td>
<td>1</td>
</tr>
<tr>
<td>-post-traumatic hematoma</td>
<td>1</td>
</tr>
<tr>
<td>-epidermoid cyst</td>
<td>1</td>
</tr>
<tr>
<td>-testicular hemorrhagic necrosis</td>
<td>1</td>
</tr>
<tr>
<td>-hemorrhagic necrosis-atrophy</td>
<td>1</td>
</tr>
<tr>
<td>-undescendend testis</td>
<td>1</td>
</tr>
<tr>
<td>-benign Sertoli cell tumor</td>
<td>1</td>
</tr>
<tr>
<td><strong>Malignant</strong></td>
<td><strong>16</strong></td>
</tr>
<tr>
<td>-seminomas</td>
<td>8</td>
</tr>
<tr>
<td>-nonseminomatous germ cell tumors</td>
<td>8</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>-embryonal carcinoma</td>
<td>3</td>
</tr>
<tr>
<td>-teratoma, embryonal carcinoma</td>
<td>1</td>
</tr>
<tr>
<td>-seminoma, embryonal carcinoma</td>
<td>1</td>
</tr>
<tr>
<td>-embryonal carcinoma, seminoma, yolk sac tumor, teratoma</td>
<td>2</td>
</tr>
<tr>
<td>-embryonal carcinoma, teratoma, yolk sac tumor</td>
<td>1</td>
</tr>
</tbody>
</table>

The standard of reference included clinical and sonographic follow-up, surgical and histopathologic findings. All cases of acute epididymo-orchitis were confirmed by means of clinical and sonographic follow-up, until symptoms and clinical findings were completely resolved. The benign nature of post-biopsy changes and intratesticular hematoma was confirmed based on patient’s history and sonographic follow-up, with an overall duration of one month. All cases of testicular carcinomas, testicular hemorrhagic necroses, epidermoid cyst and Sertoli cell tumor were confirmed by means of histopathologic examination after surgical exploration. The time interval between MR imaging and surgery (radical orchiectomy was performed in 19 patients and testicular biopsy in patient with hemorrhagic necrosis-atrophy) was less than two weeks. Undescended testis was confirmed by means of surgical exploration before orchiopexy.

**MR imaging protocol:**

MR imaging was performed on a 1.5 T Intera scanner, with the use of a pelvic phased array coil. All patients were examined in supine position, with the testes placed at a similar distance from the coil, by means of a towel placed beneath them, and the penis draped on the anterior abdominal wall. Axial spin-echo T1-weighted sequences (TR/TE: 500-650/13-15 msec) and axial, sagittal and coronal fast spin-echo T2-weighted images (TR/TE: 4000/100-120 msec) were obtained, with a 3-4 mm slice thickness and a 0.5 mm gap. The image matrix was 180 x 256 mm and the field of view was 240 x 270 mm. Axial fat-suppressed T1-weighted sequences were repeated when a lesion with high T1 signal intensity was detected. Diffusion-weighted (DW) imaging (TR/TE: 3900 msec/115 msec) was also performed along the axial plane, using a single shot, multi-slice spin-echo type echo-planar diffusion pulse sequence and b-values of 0 and 900 sec/mm². Subtraction dynamic contrast-enhanced MR imaging was performed using a three-dimensional (3D) fast field-echo (FFE) sequence (TR/TE: 9/4.1 msec; flip angle: 35°; partition thickness: 4 mm; FOV: 219 X 219 mm; and matrix: 256 X 256 mm). Coronal images were obtained before and after a rapid injection of 0.2 mmol/kg of gadopentetate dimeglumine (Gd-DTPA), performed manually through a 22-gauge catheter, placed in a subcutaneous vein.
of the antecubital fossa and followed by a flush of 20 mL of physiologic saline solution. The overall injection time was less than 1 minute and seven consecutive imaging sets, each with an acquisition time of 60 seconds were acquired immediately after the start of Gd-DTPA injection. An additional axial spin-echo contrast-enhanced T1-weighted sequence was also obtained. The data set obtained immediately before administration of Gd-DTPA was subtracted section by section from all the seven data sets obtained after contrast administration, using commercially available software.

**MR imaging data interpretation:**

MR imaging data were interpreted by two radiologists, blinded to clinical and histopathologic data. Any discrepancy was resolved by consensus. The patterns of enhancement of both the normal testis and the intratesticular lesions were evaluated on the image that was maximally enhanced and were classified as heterogeneous, homogeneous and absent. More specifically, the image of maximum enhancement, as assessed visually was selected separately for normal testis and lesions for each patient. Signal intensity mean values of circular regions of interest (ROIs), as large as possible placed within normal testicular parenchyma were recorded. In cases of intratesticular abnormality, the ROI was placed on parts of maximal enhancement, with care not to include areas of hemorrhage and/or necrosis, and the aid of corresponding T1 and T2-weighted images. Special care was also taken to avoid partial-volume effects and subtraction artifacts. In testes with a benign or malignant intratesticular mass lesion, the region of interest was placed only within the lesion. In these patients, the contralateral testis was considered as 'normal' and used for ROI measurements. In patients without a lesion, the ROI was placed in both testes. Three measurements were made and averaged.

Time-signal intensity (TSI) plots of the measured MR signal in arbitrary units (a.u.) versus time in seconds (s) were assembled for each ROI. A gamma variate fitting was performed for each curve using the method of Madsen and the MATLAB computing environment [31]. The progression of enhancement in each case was classified according to the shape of the TSI curves into three types: Type I curve, presented a linear increase of contrast enhancement over the entire dynamic period; Type II curve, showed an initial upstroke, after which the signal intensity either plateaus or gradually increases in the late post-contrast period; and Type III curve, presented an initial upstroke, followed by gradual wash-out of the contrast medium (Fig. 1 on page 8).

Time I and II curves was considered to indicate a benign diagnosis and type III a diagnosis of malignancy [16]. Three parameters were also extracted from the fitted curves:

a) The Peak height $H_{\text{max}}$, defined as the maximum value of the time-signal intensity curve.

b) The time $T_{\text{max}}$, when the curve appears its maximum.
c) The average slope $S_{\text{ave}}$, defined as the mean slope of the testicular enhancement during the first 4 minutes after injection of Gd-DTPA.

According to Watanabe et al [22] we normalized the values of these parameters in the affected testis using the unaffected testis values and the formulae:

$$\text{rel}H_{\text{max}} = 100 \times (H_{\text{max}} \text{ affected}) / (H_{\text{max}} \text{ unaffected})$$

$$\text{rel}T_{\text{max}} = 100 \times (T_{\text{max}} \text{ affected}) / (T_{\text{max}} \text{ unaffected})$$

$$\text{rel}S_{\text{ave}} = 100 \times (S_{\text{ave}} \text{ affected}) / (S_{\text{ave}} \text{ unaffected})$$

The relative parameters $\text{rel}H_{\text{max}}$, $\text{rel}T_{\text{max}}$, $\text{rel}S_{\text{ave}}$ were used as independent variables in univariate and multivariate statistical analyses. Specifically, deviations from the normal distribution of their values were assessed using the Kolmogorov-Smirnov test. Patients were divided in three groups according to the final diagnosis (i.e., benign, malignant, normal) and differences between the distributions of the $\text{rel}H_{\text{max}}$, $\text{rel}T_{\text{max}}$, $\text{rel}S_{\text{ave}}$ among these groups were assessed using the Kruskal-Wallis test. Post hoc comparisons were performed with Mann Whitnney U tests and Bonferroni corrections. A chi square test was used to evaluate the association between the curve types (I, II and III) and the final diagnosis (benign, malignant, normal). Finally, a stepwise multiple logistic regression with backward selection was performed only with malignant and benign lesions, to identify among the $\text{rel}H_{\text{max}}$, $\text{rel}T_{\text{max}}$, $\text{rel}S_{\text{ave}}$ independent predictors of malignanacy. The data were analyzed using IBM SPSS ver. 20.0 and a $P < 0.05$ was considered statistically significant.
**Fig. 1:** Schematic drawing of the time-signal intensity curve types.

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
Results

MR imaging evaluation in this study included 86 testicular units in 44 men; one patient had an undescended testis and in another case calculation of the mean signal intensity values of one testis was impossible due to its small size. Fifty-nine testicular units of normal signal intensity on both unenhanced and contrast-enhanced MR sequences were evaluated. Normal testes presented moderate, homogeneous enhancement, with a gradual increase of signal intensity throughout the examination, without peak (type I curve).

Among cases of benignity, three patients with acute epididymo-orchitis (Fig. 2 on page 12, Fig. 3 on page 12, Fig. 4 on page 13, Fig. 5 on page 14) and one case with post-biopsy changes showed strong, heterogeneous enhancement, with a late peak (300 seconds), followed by either a plateau or a gradual increase of signal intensity in the late post-contrast period (type II curve). Inhomogeneous enhancement with a ring-like pattern was also seen in patient with testicular hemorrhagic necrosis-atrophy and a similar progression of contrast enhancement (type II curve). Undescended testis and one case of epididymo-orchitis showed homogeneous enhancement, with a TSI curve of type II. In three cases, including intratesticular hematoma, epidermoid cyst and testicular hemorrhagic necrosis, no lesion enhancement was revealed. Finally, benign Sertoli cell tumor showed homogeneous contrast enhancement, with an early upstroke, followed by distinct, rapid deenhancement (type III curve, Fig. 6 on page 15, Fig. 7 on page 16, Fig. 8 on page 16). All testicular carcinomas enhanced heterogeneously. An early onset of enhancement, with a rapid increase of signal intensity (represented by a steep slope) to an early peak (180 seconds), followed by gradual wash-out of the contrast medium (type III curve, Fig. 9 on page 17, Fig. 10 on page 18, Fig. 11 on page 19) was seen in cases of malignancy. The patterns of contrast enhancement of various intratesticular mass lesions, including normal testis are summarized in Table 2.

Table 2. Enhancement patterns of various intratesticular mass lesions, including normal testis.

<table>
<thead>
<tr>
<th>Patterns of enhancement</th>
<th>Progression of enhancement (curve type)</th>
<th>Final diagnosis</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heterogeneous</td>
<td>Homogeneous</td>
<td>Absence</td>
<td>I</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>59</td>
<td>0</td>
<td>59</td>
</tr>
</tbody>
</table>
Median and range values for the parameters rel$H_{\text{max}}$, rel$T_{\text{max}}$ and rel$S_{\text{ave}}$ in benign, malignant and normal groups are presented in Table 3.

Table 3. Descriptive statistics and P values of the Kruskal Wallis for the parameters rel$H_{\text{max}}$, rel$T_{\text{max}}$ and rel$S_{\text{ave}}$.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Benign</th>
<th>Malignant</th>
<th>Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>rel$H_{\text{max}}$</td>
<td>median 163.2</td>
<td>150.3</td>
<td>90.6</td>
</tr>
<tr>
<td></td>
<td>[range] [67.4-338.0]</td>
<td>[82.5-254.4]</td>
<td>[59.8 - 113.4]</td>
</tr>
<tr>
<td></td>
<td>P value &lt; 0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rel$T_{\text{max}}$</td>
<td>median 100.0</td>
<td>57.1</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>[range] [50.0-166.7]</td>
<td>[16.7-100.0]</td>
<td>[87.5-133.3]</td>
</tr>
<tr>
<td></td>
<td>P value &lt; 0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rel$S_{\text{ave}}$</td>
<td>median 240.3</td>
<td>223.1</td>
<td>81.7</td>
</tr>
<tr>
<td></td>
<td>[range] [50.7-1600.0]</td>
<td>[118.8-467.4]</td>
<td>[52.3 - 160.0]</td>
</tr>
<tr>
<td></td>
<td>P value &lt; 0.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Boxplots in Fig. 12 on page 20, Fig. 13 on page 21, Fig. 14 on page 22 depict information in Table 3 (along with the interquartile range).

The non parametric ANOVA analysis (Kruskal-Wallis test) revealed differences in the median values of rel$H_{\text{max}}$, rel$T_{\text{max}}$ and rel$S_{\text{ave}}$ between benign, malignant and normal groups (P < 0.001, Table 3). Post hoc analysis confirmed what is evident from the visual inspection of Fig. 12 on page 20, Fig. 13 on page 21, Fig. 14 on page 22:

a) Median values of rel$H_{\text{max}}$ and rel$S_{\text{ave}}$ differ between intratesticular lesions (benign or malignant) and normal cases (P < 0.001), but do not differ between benign and malignant groups (P: 0.683 for rel$H_{\text{max}}$ and P: 0.605 for rel$S_{\text{ave}}$).

b) Median values of rel$T_{\text{max}}$ differ between malignant and non-malignant groups (including benign and normal cases) (P < 0.001), but do not differ between normal cases and benign intratesticular lesions (P: 0.597).

A strong association (P < 0.001) was found between the type of the time-signal intensity curve and the final diagnosis. Specifically, type I curve was found in all (100%) normal cases, type II curve was found in 63.6 % of benign cases and type III curve was found in all (100%) cases of malignancy (Table 2).
Logistic regression analysis revealed that only relT$_{\text{max}}$ is independent predictor of malignancy (regression coefficient: - 0.103; likelihood ratio: 29.2; P value: < 0.001; adjusted odds ratio: 0.902; 95% confidence interval: 0.850-0.957).
**Fig. 2:** Right epididymo-orchitis in a 75-year old man. Sagittal T2-weighted image demonstrates enlargement and hypointensity of the right epididymal tail (arrowhead). The ipsilateral testis is also of low signal intensity. A moderate amount of right hydrocele (arrow) is seen.

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
**Fig. 3:** Same patient as in figure 2. Coronal dynamic contrast-enhanced subtracted image at delayed (360 sec) phase shows strong, progressive increase of signal intensity of right testicular parenchyma. Both the right epididymis (arrowhead) and the ipsilateral testis enhances inhomogeneously. Left testis (asterisk) enhances homogeneously, with gradual increase of signal intensity during the entire dynamic period.

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
**Fig. 4:** Same patient as in figures 2,3. TSI curve of right orchitis (type II; a.u., arbitrary units; s, seconds)

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
Fig. 5: Same patient as in figures 2,3,4. TSI curves of normal contralateral testis (type I; a.u., arbitrary units; s, seconds).

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
**Fig. 6:** Benign Sertoli cell tumor of the left testis in a 22-year old man. Sagittal T2-weighted image depicts a small, ill-defined intratesticular mass (long arrow), of low signal intensity. A small amount of hydrocele (arrow) is also detected isilaterally.

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR

**Fig. 7:** Same patient as in figure 6. Coronal dynamic contrast-enhanced subtracted image at early (180 sec) phase shows strong, homogeneous lesion enhancement (long arrow).

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
**Fig. 8:** Same patient as in figures 6,7. TSI plot of the neoplasm is strongly suggestive of malignancy (type III; a.u., arbitrary units; s, seconds)).

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
**Fig. 9:** Left testicular seminoma in a 30-year old man. Coronal T2-weighted image depicts left intratesticular mass (arrow), mainly hypointense.

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
**Fig. 10:** Same patient as in figure 9. Coronal dynamic contrast-enhanced subtracted images at early (180 sec) phase, show strong, heterogeneous enhancement of the neoplasm, followed by deenhancement. Central area (asterisk) within the mass that does not enhance corresponded to necrosis on pathology.

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
**Fig. 11:** Same patient as in figures 9, 10. TSI curve of the tumor is typical of malignancy (type III; a.u., arbitrary units; s, seconds).

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
**Fig. 12:** Boxplot of relHmax value in the malignant, benign and normal groups.

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
Fig. 13: Boxplot of relTmax value in the malignant, benign and normal groups.

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
Fig. 14: Boxplot of relSave value in the malignant, benign and normal groups.

© Dept. of Radiology, University Hospital of Ioannina - Ioannina/GR
Conclusion

Although rare, benign intratesticular lesions, including tubular ectasia of rete testis, epidermoid cyst, testicular infarction, fibrosis, hematoma and orchitis should be accurately characterized, to avoid unnecessary radical orchiectomy. An alternative treatment planning, including follow-up, biopsy or partial orchiectomy may be justified in these patients. MR imaging of the scrotum has shown satisfactory results in the evaluation of diverse scrotal diseases, especially recommended in cases of nondiagnostic sonographic features or inconsistent with clinical findings [1-14]. MR imaging findings, with respect to tumor location, morphologic features and tissue characterization, can aid in narrowing the differential diagnosis in cases of intratesticular masses, by showing the presence of fat, blood products, fibrosis, fluid and solid tissue [1-14].

MR imaging examination of the scrotum, including dynamic contrast-enhanced technique may provide valuable information about testicular enhancement, therefore improving the diagnostic performance of the technique in lesion characterization [22-30]. Reinges et al in a study of 20 volunteers and 15 patients with intratesticular lesions noted that the maximum increase of signal intensity (peak height) during DCE MR imaging was significantly higher in malignancies when compared to normal testis [25]. Watanabe et al in a study of 42 patients with various scrotal diseases concluded that DCE subtracted MR imaging can be used to diagnose scrotal disorders and differentiate testicular diseases from extratesticular lesions [22]. More specifically, time-signal intensity curves of extratesticular diseases reported similar to normal testicular parenchyma. Regarding intratesticular lesions, the authors reported low relative percentages of peak height and mean slope for a group with no or decreased enhancement, including testicular torsion, infarction, epidermoid cyst and testicular hemorrhagic necrosis and high relative percentages of both parameters for a group with increased contrast enhancement, including testicular carcinoma and acute mumps orchitis [22].

The present study is one of the first reports on the usefulness of DCE subtracted MR imaging in characterizing the nature of intratesticular mass lesions. Both patterns and progression of enhancement were assessed in characterizing intratesticular masses. The shape of the signal intensity-versus-time curves was analyzed and correlated to the final diagnosis. Three parameters were used to quantify testicular perfusion, including relative percentages of peak height and average slope, already reported in the literature and relative percentages of time to peak, not previously mentioned.

Our results showed that normal testis enhances moderately and homogeneously, with a linear increase of signal intensity during the entire dynamic period (type I curve, Figure 2d). This was in accordance with other published series and was probably related to an intact ‘blood-testis’ barrier [22, 25]. The patterns of contrast enhancement of benign intratesticular lesions varied from absent to homogeneous or heterogeneous
enhancement, the latter closely resembling malignancies. Although, the absence of contrast enhancement has been previously reported as a sensitive sign for predicting the benign nature of intratesticular masses, characterization may be difficult for contrast-enhancing lesions [7]. Our results indicate that the relative percentages of peak height and the relative percentages of average slope on the basis of TSI plots do not differ between benign and malignant intratesticular lesions, although different when comparing normal testis and intratesticular masses. Both testicular carcinomas and benign lesions showed an initial upstroke (represented by a steep slope in TSI curve), but malignancies had an early onset of enhancement, followed by gradual deenhancement (type I curve). On the contrary, benign intratesticular lesions presented either a plateau or a progressive increase of signal intensity at the delayed phase (type II curve). Based on our results, the relative percentages of time to peak proved the most reliable discriminating factor in the characterization and differentiation of intratesticular masses.

The increase of signal intensity after the intravenous administration of paramagnetic low-molecular-weight contrast agents depends on tissue perfusion, capillary permeability and volume of the extravascular-extracellular space. More specifically, early changes in TSI curves correlate with blood supply, since contrast agent is mainly confined within the vascular bed, and late changes are related to extravascular-extracellular accumulation of contrast material, the latter influenced mainly by the permeability of the capillaries [15]. On DCE-MR imaging, malignancies typically show rapid and intense contrast enhancement followed by deenhancement, which is faster than normal background, and this was also proved in this study. Rapid, early contrast medium enhancement seen in carcinomas, is believed to be caused by tumor angiogenesis. It is known that growth of malignancies depends on angiogenesis and that increased tumor-associated vascularity results from neovasculature formation [15-21].

Benign Sertoli cell tumor in this report was detected with a relative signal change much higher than that of other testicular carcinomas, showing a strong, early contrast enhancement, with a homogeneous pattern, followed by rapid deenhancement. The same features were also reported by Reinges et al and could probably be used to differentiate this rare neoplasm from germ cell testicular carcinomas [25].

Recently, several other MR imaging techniques have been reported for the evaluation of testicular perfusion, including diffusion-weighted MRI, arterial spin-labeling perfusion MRI and DCE MRI using blood-pool contrast agents [32, 33]. Contrast-enhanced sonography was also reported as a useful technique for the assessment of testicular blood flow in patients with acute scrotum, especially in cases of nondiagnostic ultrasound findings, including testicular trauma, infarction and partial testicular torsion [34].

There were limitations in this study. First, it was a retrospective review of a small series, including only one case of solid benign intratesticular lesion. A larger number of patients, including a variety of benign intratesticular masses is needed in order to validate our results. Furthermore, MR imaging interpretation data was performed by two radiologists in consensus, and so no interobserver reliability was assessed.
In concluding, DCE subtracted MR imaging can be used to differentiate benign from malignant intratesticular mass lesions. The evaluation of time-signal intensity curves could provide useful diagnostic information, with the relative percentages of maximum time to peak proved the most reliable factor for lesion characterization. However, prospective studies comparing the diagnostic performances of DCE MR imaging with sonographic examination, including contrast-enhanced ultrasound are required, in order to further establish the clinical value of the technique.
References


Personal Information

Athina C. Tsili\textsuperscript{1}, Alexandra Ntorkou\textsuperscript{1}, Aikaterini Ntoulia\textsuperscript{1}, Anastasios Silakos\textsuperscript{2}, Nikolaos Sofikitis\textsuperscript{2}, Maria I. Argyropoulou\textsuperscript{1}

\textsuperscript{1}Department of Clinical Radiology

\textsuperscript{2}Department of Urology

University Hospital of Ioannina, Ioannina, Greece.