Microvessel Density: Correlation between Contrast Ultrasonography and Histology of Prostate Cancer

J.P. Michiel Sedelaar\textsuperscript{a}, Geert J.L.H. van Leenders\textsuperscript{b}, Christian A. Hulsbergen-van de Kaa\textsuperscript{b}, Henk G. van der Poel\textsuperscript{a}, Jeroen A.W.M. van der Laak\textsuperscript{b}, Frans M.J. Debruyne\textsuperscript{a}, Hessel Wijkstra\textsuperscript{a}

Departments of \textsuperscript{a}Urology and \textsuperscript{b}Pathology, University Medical Center, Nijmegen, The Netherlands

Abstract

Objective: Increased microvessel density (MVD) of prostate cancer seems to be associated with poor prognosis and higher stage. Assessment of MVD using noninvasive methods could be of use in the work-up of patients with prostate cancer. The aim of the present study was to correlate three-dimensional contrast-enhanced power Doppler ultrasound (3D-CE-PDU) findings with MVD characteristics of radical prostatectomy specimens.

Methods: Seven patients with biopsy-proven prostate cancer had 3D-CE-PDU investigations 2–3 weeks after prostate biopsies were taken and prior to radical prostatectomy. The investigations were performed using Levovist\textsuperscript{®} contrast agent (Schering AG, Berlin, Germany) in combination with a Voluson 530D\textsuperscript{®} ultrasound scanner (Kretz AG, Zipf, Austria). The 7 patients were selected because of lateralization of the contrast enhancement. Histology slides were made of the side with ‘contrast enhancement’ and of the contralateral ‘unenhanced’ side and stained according to the catalyzed reporter deposition (CARD) amplification procedure, and MVD parameters were obtained.

Results: In all patients the MVD count of the ‘enhanced’ side was higher than the MVD count of the ‘unenhanced’ side, averaging 1.93 times higher. On histology all enhanced lesions proved to contain prostate cancer tissue (average maximum diameter 25 mm (range 17–31)). Two patients had a small bilateral tumor lesion (4 and 5 mm respectively) and in total 5 patients had even smaller satellite lesions (1–2 mm). The smaller lesions were not identified using 3D-CE-PDU.

Conclusions: The present study shows that 3D power Doppler contrast ultrasonography is a minimally invasive imaging modality, which has the potential to visualize lesions with increased MVD. This property of 3D-CE-PDU could be used in the detection of prostate cancer.

Key Words

Microvessel density count · Prostate carcinoma · Contrast ultrasonography · 3D ultrasound imaging
Introduction

Fregene et al. [1] were among the first to report on the possible clinical and pathological significance of tumor-associated angiogenesis in prostate cancer. This increased angiogenesis in prostate cancer is generally referred to as increased microvessel density (MDV).

A number of different potentials of the use of MVD in prostate cancer were discussed in recent publications: as a possible predictor of pathological stage, i.e. prediction of extraprostatic extension of prostate cancer [2], as a means to stratify patients for different therapies [3] and a possible prognostic indicator and prediction of cancer-specific survival [4–8]. All these studies concluded that an increase in MVD was found to be associated with a poor prognosis, higher tumor stage, a more extensive extraprostatic tumor growth, and had the potential to be of importance with regard to making the diagnosis and follow-up in patients with prostate cancer. Siegal et al. [9] found approximately a twofold increase in MVD of prostate cancer when compared to benign prostate tissue. However, not all studies agreed on this. Several investigations could not confirm a correlation between MVD and clinical and/or biochemical recurrence in stage T2 or T3 prostate cancer [10, 11].

Despite a more critical view, MVD research continues to attract special attention. An increase of MVD could have value in making the clinical diagnosis of prostate carcinoma if this increase in vessel density can be detected using non-invasive (imaging) modalities such as contrast ultrasonography. For many other organs the value of contrast ultrasound investigations has already been demonstrated [12–14]. Contrast ultrasonography studies seemed to be of additional value over conventional ultrasound investigations in the evaluation of possible pathology. These evaluations of pathology were based on the assessment of the vascularity. With regard to the prostate, only a limited number of studies are performed concerning the use of contrast ultrasonography in the diagnosis of pathology [15, 16]. These studies indicated additional value of contrast ultrasonography in the evaluation of prostate cancer.

The aim of the present study was to correlate contrast ultrasonic findings with the histopathologic substrate from the radical prostactectomy specimens. The objective was to compare the MVD of the enhanced lesions with the MVD of the contralateral 'normal' side.

Patients and Methods

Seven patients with biopsy-proven prostate cancer underwent three-dimensional contrast-enhanced power Doppler ultrasonography (3D-CE-PDU) prior to radical retropubic prostatectomy. The 3D-CE-PDU investigations were performed 2–3 weeks after sextant prostate biopsies were taken, to exclude possible interference of biopsy effect on the vascularity of the prostate. For the purpose of this study, patients with clear lateralization of contrast enhancement were selected to investigate the microvessel characteristics of the enhanced and unenhanced side of the prostate. All 7 patients had a lateralization of contrast enhancement and were included in the study protocol. The asymmetry of the enhancement of the 3D-CE-PDU images was assessed both subjectively by one ultrasound expert and objectively by a specially designed computer program on the ultrasound scanner. This computer program assesses in a histogram mode the number of colored pixels as a percentage of the number of gray pixels.

The ultrasound examinations were performed using a Kretz Volumen 530D ultrasound scanner with 3D S-VDW 5–8 MHz end-fire probe (Kretz Technik AG, Zipf, Austria). With the use of this transrectal probe it is possible to scan a 3D volume with an angle of 95°, enabling the examiner to capture the prostate from apex to base in one 3D volume scan. The 3D volume scan was made using the power Doppler mode, and was performed 1 min after the start of the contrast infusion. The 3D ultrasound images were stored digitally on hard disk and on video (S-VHS) to allow off-line analysis. The contrast ultrasonography investigations were performed using 2.5 g. Levovist microbubbled ultrasound contrast agent (Schering AG, Berlin, Germany), in an 7-cm³ solution, administered via an antecubital vein of the right arm using an 18-gauge intravenous cannula (Venflon 2, Ohmeda AB, Helsingborg, Sweden). The contrast infusion was given at a rate of about 0.35–0.50 ml/s to slowly distribute the contrast to the blood pool, and thus extend the ultrasound scanning time. Immediately after the administration of the ultrasound contrast medium, an injection of 10 ml of 0.9% sodium chloride solution was injected to flush the intravenous cannula.

A standard radical retropubic prostatectomy was performed 1–7 days after the 3D-CE-PDU investigations. Following surgery the prostatectomy specimens were fixed by microwave-stimulated formalin fixation [17] and subsequently cut into serial transverse 4-mm slices.

Using the 3D-CE-PDU images, the lesion with the most asymmetrical enhancement was identified, and its position (left or right) and distance from the base of the prostate was measured. This location was extrapolated on the whole-mount prostatectomy specimen to produce a histology slide of the enhanced lesion, as well as a slide of the contralateral ‘unenhanced’ side of the same prostate.

A vessel-staining technique combined with computer hard- and software, especially designed for MVD counts [18, 19] was used. MVD characteristics were obtained and statistical analysis was performed.

Paraffin-embedded 4-µm slides were stained with hematoxylin and eosin (HE) for histopathologic evaluation. For quantitative analysis of blood vessels, representative slides were stained according to the catalyzed reporter deposition (CARD) amplification procedure [20]. Tissue sections of 4 µm were deparaffinized with xylene and rehydrated in 100% methanol. Endogenous peroxidase was blocked with 1% H₂O₂/methanol for 20 min followed by rinsing in methanol and phosphate-buffered saline (PBS).
The slides were preincubated with 100% normal horse serum for 20 min and then incubated with CD34 antibody (1:2) (BioGenex) overnight at 4 °C, followed by biotinylated horse anti-mouse antibody (1:200) (Brunsche Chemie) for 30 min and horseradish peroxidase-labelled avidin-biotin complex (1:100) (Vector Laboratories) for 30 min. Signal amplification was performed with biotinylated tyramide (1:50) for 5 min, followed by another incubation with horseradish peroxidase-labelled avidin-biotin complex for 20 min [21]. Finally, horseradish peroxidase was visualized with 0.05% 3,3'-diaminobenzidine (Sigma) in PBS containing 0.15% hydrogen peroxide for 5 min in the dark. The sections were counterstained with hematoxylin. All washings between the incubations were performed in PBS and all antibodies were diluted in PBS containing 1% bovine serum albumin.

The MVD characteristics were obtained using a Vidasplus system (Kontron GmbH, Eching, Germany). The quantification method using the Vidasplus system has been the subject of a study in which this method was tested against other vessel quantification techniques. This study showed that the Vidasplus system was more reproducible than manual assessment of microvessel characteristics, and that the method yields data that accurately described the morphology of individual microvessels [18]. Color microscopic images were recorded by a CCD camera (DXC-325P, Sony, Japan) mounted on top of a conventional light microscope (Axioskope, Carl Zeiss, Germany) using a 10× objective. Microscopic fields covering the entire prostate tumor area as well as the fields covering the normal prostate tissue were digitized and stored on magneto-optical disk as true color (24-bit RGB) images. A reference image of an empty field was recorded before the measurements for the correction of unequal illumination (shading correction). Prostate tissue (either malignant or normal) stained with CARD am-
sue. These regions could interactively be excluded from further analysis. Finally, parameters were calculated describing the size and shape of individual vessel profiles and the number of vessel profiles per unit area. Of each histology slide (prostate tumor and normal prostate tissue), a total of 30 microscopy fields were included in the Vidasplus system analysis. The number of blood vessels, the average % of stained area per field and the total perimeter of stained vessel per field of the enhanced side and of the unenhanced side of the prostate were compared and statistically analyzed. The statistical analysis was performed using the Student t-test.

### Results

The patient characteristics and clinical parameters, the histology characteristics of the prostate biopsies and of the radical prostatectomy specimens are given in table 1. All patients had clinically localized prostate cancer, and radical surgery was performed. The postoperative histology showed pT2, 3× pT3 (2× capsular penetration and 1× extension in the seminal vesicles) and 1× pT4 (extension in the bladder neck).

The gray scale ultrasound images all revealed either benign nonsuspicious prostate tissue or a suspicious hypoechoic lesion on one side of the prostate (uT0-2). At a detailed inspection of the gray scale ultrasound images, no abnormalities were seen either indicating either capsular penetration or seminal vesicle involvement. When examining the 3D-CE-PDU images in all subjects, a single unilateral lesion with clear contrast enhancement was found. Three of the investigations revealed a suspicious lesion in the vicinity of the capsula, and was therefore classified as a contrast-enhanced-T3 lesion, and indeed in 2 patients a capsular penetration was confirmed. No indication for seminal vesicle involvement was found using 3D-CE-PDU studies. When investigating the amount of contrast enhancement,
Table 2. Objective assessment of asymmetry (histogram mode)

<table>
<thead>
<tr>
<th>Patient</th>
<th>Side of positive prostate biopsy</th>
<th>Objective assessment of side of asymmetry, %</th>
<th>Subjective assessment of side of asymmetry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R</td>
<td>R: +1.03</td>
<td>R</td>
</tr>
<tr>
<td>2</td>
<td>R</td>
<td>R: +1.21</td>
<td>R</td>
</tr>
<tr>
<td>3</td>
<td>R</td>
<td>R: +2.43</td>
<td>R</td>
</tr>
<tr>
<td>4</td>
<td>L</td>
<td>L: +2.52</td>
<td>L</td>
</tr>
<tr>
<td>5</td>
<td>R</td>
<td>R: +0.74</td>
<td>R</td>
</tr>
<tr>
<td>6</td>
<td>L</td>
<td>L: +0.98</td>
<td>L</td>
</tr>
<tr>
<td>7</td>
<td>L</td>
<td>L: +1.24</td>
<td>L</td>
</tr>
</tbody>
</table>

In this table, values per patient, the side of positive prostate biopsy, side of objective assessment of asymmetry (using the histogram mode of the ultrasound scanner Voluson 530D, Kretz AG) and the side of subjective assessment of asymmetry by visual inspection of the 3D-CE-PDU images are given. The objective assessment of asymmetry side is given in percentage, i.e. percentage of colored pixels relative to the number of gray scale pixels.

Fig. 1. Three examples of 3D-CE-PDU enhancement. On the left a 2D contrast-enhanced power Doppler examination, on the right the matching 3D reconstruction. The top two images are from patient 3, the middle two images are from patient 5. Both patients have an asymmetrical enhancement. It is clearly noticeable that patient 3 had a more outspoken contrast enhancement than patient 5. The bottom two images are from a patient with clinically benign prostate hyperplasia and no asymmetrical enhancement is seen.

some differences were seen. Although vascular asymmetry was very clear in all patients, not all prostates had a similar extent of vascular enhancement. This is illustrated in figure 1.

The histogram mode showed relatively increased number of colored pixels on the side identified by visual assessment when compared to the contralateral side (table 2). All but 2 patients had one or more small satellite multilocular lesions of prostate cancer surrounding the main (e.g. largest) prostate tumor. The most satellite tumors were found with the largest main tumors. The average maximum diameter of the identified prostate cancer lesions was 25 mm (range 17–31). The two contralateral lesions were small (i.e. 4 and 5 mm) and identified preoperatively. The satellite lesions were 1–2 mm. The largest diameter of the main tumors, contralateral tumor and multifocality is given in table 3.

The results of the MVD evaluation shown an increase in the number of blood vessels in the ‘enhanced’ slide (identified as prostate cancer on histology), as compared to ‘unenhanced’ slide (identified as benign prostate tissue on histology).
Table 3. Multifocality of prostate cancer

<table>
<thead>
<tr>
<th>Patient</th>
<th>Largest diameter mm</th>
<th>Contralateral tumor Y/N</th>
<th>Satellite tumors n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31</td>
<td>Y (5 mm)</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
<td>N</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>21</td>
<td>N</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>17</td>
<td>N</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>Y (4 mm)</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>23</td>
<td>N</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>30</td>
<td>N</td>
<td>1</td>
</tr>
</tbody>
</table>

Per patient the maximum diameter of the detected tumor is given (in mm). Also the size of a contralateral tumor (if identified) is given (in mm) as well as the number of small multifocal satellite tumors.

Fig. 2. Example of asymmetrical enhancement, with corresponding histology slides. On the left side of the image (right side of the prostate) the asymmetry is notable. The histology slide of this side shows increased MVD coloring, compared with the contralateral, benign slide.

Due to intensified screening of prostate cancer, more patients are diagnosed at an earlier stage and earlier age [25, 26]. However, the current diagnostic modalities, especially the imaging modalities like ultrasound and MRI, are still insufficient for the diagnosis or correct staging of all clinically relevant prostate tumors. This has resulted in a universal search for better imaging modality [27] which focuses mainly on the vascularity of the prostate [28, 29]. Although considerable controversy remains concerning the prognos-

Discussion

The significant increase in blood vessels number of the malignant slide is shown in all blood vessels size categories (<25, >25, >50, >100 and >200 µm), in all but 2 patients (Nos. 1 and 5). With decreasing size of the blood vessels this difference between malignant and benign tissue is more outspoken. On average the malignant component had 1.93 (1.01–4.13) times more blood vessels. This relationship is given for each patient in figures 3 and 4.
Table 4. MVD parameters

<table>
<thead>
<tr>
<th>Patient</th>
<th>Average field count</th>
<th>Area p</th>
<th>Average field perimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>enhanced unenhanced</td>
<td></td>
<td>enhanced unenhanced p</td>
</tr>
<tr>
<td>1</td>
<td>43.1 (1–92)</td>
<td>32.3 (6–83)</td>
<td>0.027</td>
</tr>
<tr>
<td></td>
<td>6.2 (1–16)</td>
<td>5.2 (1–13)</td>
<td>0.489 a</td>
</tr>
<tr>
<td>2</td>
<td>62.1 (20–107)</td>
<td>23.5 (1–54)</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>6.2 (2–11)</td>
<td>3.6 (1–9)</td>
<td>0.008</td>
</tr>
<tr>
<td>3</td>
<td>52.6 (14–100)</td>
<td>31.7 (7–85)</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>7.6 (3–25)</td>
<td>4.9 (1–11)</td>
<td>0.046</td>
</tr>
<tr>
<td>4</td>
<td>32.5 (15–60)</td>
<td>23.9 (10–42)</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>6.2 (3–18)</td>
<td>4.1 (1–10)</td>
<td>0.233 a</td>
</tr>
<tr>
<td>5</td>
<td>41.2 (8–83)</td>
<td>38.4 (10–71)</td>
<td>0.291 a</td>
</tr>
<tr>
<td></td>
<td>5.2 (1–18)</td>
<td>6.2 (2–25)</td>
<td>0.082</td>
</tr>
<tr>
<td>6</td>
<td>68.2 (17–111)</td>
<td>14.5 (5–52)</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>7.1 (1–19)</td>
<td>2.8 (1–6)</td>
<td>0.001</td>
</tr>
<tr>
<td>7</td>
<td>40.4 (14–79)</td>
<td>20.8 (7–54)</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>6.4 (1–18)</td>
<td>3.6 (1–15)</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Vascular characteristics of the tumor histology slides and the benign histology slide. Average field count = Average number of vessel profiles in a field, in parentheses the dispersion; area p = average % of stained area in a field, in parentheses the dispersion; average field perimeter = average perimeter of vessel profiles in a field (in µm), in parentheses the dispersion. For all parameters the correlation is calculated using the Student t-test. a p value not statistically significant different.

The 3D imaging modality makes it possible to evaluate the ultrasound images of the whole prostate, after the patient has left the office.

In this study we selected patients with a clear lateralization of contrast enhancement, in order to compare the microvessel characteristics of the enhanced and unenhanced side of the prostate. The detection of asymmetry of increased contrast enhancement was performed subjectively using visual inspection of the 3D-CE-PDU images, as well as objectively using a special computer mode on the ultrasound scanner (histogram mode). The results demonstrate that in this small selected group an increased MVD can be detected that correlates well with the corresponding findings of the 3D-CE-PDU studies.

We identified an average of 1.93 times increased MVD count in the tumor component when compared with the benign component. This increase in vessel count was most notable with the smallest blood vessels. This is in accordance with the knowledge of an increased microvessel count in prostate tumor tissue compared with benign tissue [29]. The average maximal diameter of the detected prostate cancer was 25 mm (range 17–31).

Small prostate cancer lesions however, could not be detected using 3D-CE-PDU studies. In 2 patients the difference between the MVD count of the benign and malignant component was not statistically significant different. On histology these 2 patients had a large prostate tumor (25 and 31 mm diameter respectively) on the side identified with 3D-CE-PDU and a small contralateral prostate tumor (4 and 5 mm diameter respectively). The manner of identifying abnormality in vascularity of the prostate using 3D-CE-PDU was based on identifying asymmetry of the contrast value of neovascularization in prostate cancer, this increased MVD could be used to visualize prostate cancer.

To improve ultrasound investigations of the prostate, we are currently investigating the value of transrectal 3D-CE-PDU of the prostate in the detection and localization of prostate cancer. In the present study we aim to demonstrate that 3D-CE-PDU has the potential to detect an increased MVD in the prostate which correlates with prostate cancer.

![Fig. 3. Distribution of blood vessels. For each patient the blood vessels sizes of the tumor (T) and benign (B) slides are shown. Blood vessels sizes are shown in categories: <25, >25, >50, >100 and >200 µm.](image-url)
Fig. 4. Graphic representation of the number of blood vessels per patient. On the x-axis, 5 blood vessel size categories are represented (1 = <25, 2 = ≥25, 3 = ≥50, 4 = ≥100 and 5 = ≥200 µm). On the y-axis, the number of blood vessels is given. The continuous line (—) represents the number of blood vessels on the malignant slide, while the dashed line (---) represents the number of blood vessels on the benign slide. The total number of blood vessels of the malignant and benign sides are correlated with each other, using the Student t-test. In all but 2 patients (Nos 1 and 5: p = 0.142 and p = 0.566 respectively) the difference between the number of blood vessels in malignant and benign tissue is statistically significant. Patients 1 and 5 had bilateral prostate carcinoma.
contrast enhancement. This could explain the fact that in the 2 patients with bilateral prostate cancer, only the largest tumor was identified. However it must be questioned if a small tumor of 4/5 mm in diameter could explain the lack of difference in MVD count both on the benign and on the tumor side in patient 5. Also, 5 of the 7 patients had one or more satellite prostate cancer lesions surrounding the main tumor. These even smaller lesions (1–2 mm diameter) could not be detected using 3D-CE-PDU. The explanation for not detecting these abnormalities with 3D-CE-PDU or with the MVD count is that these small prostate cancer lesions do not have an outspoken increased MVD when compared to larger tumors.

In the patient group no relationship was found between the amount of MVD and the Gleason score of the radical prostatectomy specimens. Although Mydlo et al. [30] found a higher MVD count with increasing Gleason score, we were not able to confirm these results. This could well be explained by the fact that we had a small patient group, with minimal difference in Gleason score.

The increased MVD count on the side with the contrast enhancement (the tumor side) was noted in all blood vessel size categories, but most notably in the small blood vessel. This could be explained by the fact the neovascularization is relatively uncontrolled, resulting in the formation of numerous new blood vessels at the same time, which will probably not all evolve in larger blood vessels.

If a prostate tumor is identified, the next step is to provide an adequate staging of the disease. As mentioned before, staging methods used nowadays, including a physical examination, transrectal ultrasound studies of the prostate, CT scan or MRI of the abdomen and if indicated a bone scan, are not good enough to accurately stage the local extent of the disease. To illustrate this, after our standard (physical examination and gray scale TRUS) we identified 5 times a T2 lesion of the prostate while twice no abnormality could be found (T1 lesion). After surgery, 3× T2, 3× T3 and 1× T4 prostate cancer was found. In 2 out of 7 (28.5%) patients a correct staging was obtained, when using physical examination and gray scale imaging. When examining the 3D-CE-PDU images, 4× T2 and 3× T3 prostate cancer was identified. The investigators were blinded from the definitive pathology staging. The correct staging of the 3D-CE-PDU studies was 5 out of 7 (71.4%).

It is too early to draw definitive conclusions from this small survey, but the obvious difference in staging accuracy is striking.

It should be mentioned that the size of our study group is too small to draw any definite conclusions regarding the detection and staging of prostate cancer using 3D-CE-PDU. However, the strong correlation between contrast enhancement and the presence of increased MVD make 3D-CE-PDU a useful tool to detect increased MVD in the prostate.

3D-CE-PDU can provide two different kinds of information: static and dynamic information. In this study the static (anatomic) information was used, obtained by 3D-CE-PDU by assessing asymmetry of the blood vessel architecture in the prostate of patients with biopsy-proven localized prostate cancer. Asymmetry correlated well with an increased MVD and was shown successful in identifying large prostate tumors, but failed to identify small contralateral tumors and multifocal lesions. The 2 patients (Nos 1 and 5) with unilateral contrast enhancement, but with bilateral prostate tumors (although small tumors), illustrate the shortcoming of using only the static or anatomical information provided by contrast ultrasound studies.

The hemodynamic behavior is left out of consideration in the presented study. By assessing the dynamic contrast enhancement of prostate blood vessels, it would be possible to study the hemodynamic behavior of prostate blood vessels and possibly identify prostate cancer lesions, as postulated by Aarnink et al. [31]. By using the dynamic technique it would in theory be possible to detect very small variations in hemodynamic behavior caused by the formation of new (small) tumor blood vessels and thus identify prostate tumor. Although these alterations in hemodynamics would probably not be too subtle to detect with the human eye, these alterations could be detected by using computer software. However, improvement of the contrast enhancement technique is needed before we can start using the dynamic information.

Conclusion

It is a generally accepted assumption that prostate cancer has a higher MVD count than benign prostate tissue. Assessing the higher MVD could be used to improve the diagnosis and staging of prostate cancer, especially if the assessment of MVD is minimally invasive. The study presented shows that 3D-CE-PDU is a minimally invasive imaging modality, which has the potential to visualize lesions with increased MVD. 3D-CE-PDU could therefore be used to improve the detection and diagnosis of prostate cancer, and more studies will be performed in the near future to investigate this clinical use.
References


