—Original—

Random Systematic Sextant Biopsy Versus Power Doppler Ultrasound-guided Target Biopsy in the Diagnosis of Prostate Cancer: Positive Rate and Clinicopathological Features

Go Kimura, Taiji Nishimura, Ryoji Kimata, Yuka Saito and Kazuhiro Yoshida

Department of Urology, Nippon Medical School

Abstract

Purpose: To determine the efficacy of power Doppler ultrasound (PDU) in the diagnosis of prostate cancer, the rate of detection of cancer with PDU-guided target biopsy and sextant biopsy, the clinicopathological features of cancer positive specimens, and the relation between these two findings were studied.

Methods: From January 1998 through March 2000, 302 men suspected to have prostate cancer underwent sextant biopsy in association with additional PDU-guided target biopsy. Cases with positive biopsy results were divided into 9 groups as follows: T0: sextant biopsy was positive, but target biopsy was negative; S0: all sextant biopsies were negative, but target biopsy was positive; S1～S6: both sextant biopsy and target biopsy were positive (number indicates number of positive sextant biopsy); Tx: sextant biopsy was positive, but no target biopsy was performed owing to a lack of echogenic abnormalities. The Gleason score (GS) and percent organ confined disease (%OCD) were compared between these 9 groups.

Results: Cancer was pathologically detected in 143 of 302 patients (47.4%). PDU detected 39 of 49 digital rectal examination-negative cancers (79.6%) and 5 of 13 transrectal ultrasound-negative isoechoic cancers (38.5%). Of 143 biopsy-positive cases, 6 were in the T0 group (4.2%), 10 in S0 (7.0%), 119 in S1～S6 (83.2%), and 8 in Tx (5.6%). Target biopsy missed 14 (sum of T0 and Tx) cancers, and sextant biopsy missed 10 (S0). The average GS in the Tx group was significantly lower than that in the other groups; consequently, the %OCD was significantly higher. Retrospective analysis revealed that the failure to obtain cancer tissue in 4 of the 6 cases in the T0 group is most likely due to technical failure in obtaining specimens. The overall sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of PDU were 90.2%, 77.4%, 78.2%, 89.8% and 83.4%, respectively.

Conclusion: PDU in association with sextant biopsy is a useful tool for increasing the rate of detection of prostate cancer. Further advances in ultrasound technology may enable the detection of prostate cancer by target biopsy alone and consequently may reduce the number of unnecessary biopsies. However, PDU-guided target biopsy alone is insufficient for cancer detection at the present time because of possible technical failure in obtaining specimens and the existence of PDU-negative cancer. Although more evidence is required, PDU-negative cancer is suggested to be less aggressive clinically, possibly justifying a watch and wait policy.
(J Nippon Med Sch 2005; 72: 262–269)

Correspondence to Taiji Nishimura, Department of Urology, Nippon Medical School, 1–1–5 Sendagi, Bunkyo-ku, Tokyo 113–8603, Japan
E-mail: gokimura@nms.ac.jp
Journal Website (http://www.nms.ac.jp/jnms/)

Key words: prostate cancer, power Doppler ultrasound, diagnosis, biopsy

Introduction

More than 10 years have passed since Hodge et al.[1] introduced systematic sextant biopsy as an alternative to lesion-directed target biopsy for the diagnosis of prostate cancer. Since transrectal ultraound (TRUS)-guided target biopsy yields insufficient positive results compared with sextant biopsy[1], sextant biopsy has become the gold standard for the diagnosis of prostate cancer. In the past decade, however, modern ultrasound technology has advanced greatly and now not only offers higher resolution but also displays blood flow signals combined with gray-scale imaging with an endorectal transducer. The use of gray-scale TRUS in the diagnosis of prostate cancer is associated with poor sensitivity and specificity. Although a hypoechoic lesion in the peripheral zone is the most common appearance of prostate cancer, it is not specific, and benign prostatic lesions also appear hypoechoic, resulting in low specificity[2]. Moreover, TRUS cannot detect isoechoic cancer, which lowers the sensitivity of this method of detecting prostate cancer[2]. For these reasons, several radiologists and urologists have attempted to use blood flow signals as a new diagnostic variable to improve diagnostic accuracy in cases of suspected prostate cancer. Initially, color Doppler ultrasound (CDU)[3–5] was used for this procedure, but more recently power Doppler ultrasound (PDU)[6–11] has been used instead because it has several benefits over CDU. In comparison with CDU, PDU is angle-independent, does not alias, and can be used at a high gain level, so can detect blood flow at much lower levels with higher sensitivity than CDU[12].

Although recent studies have evaluated the clinical efficacy of PDU in the diagnosis of prostate cancer[6–11], the clinicopathological features of PDU-negative prostate cancer have not been documented.

This prospective study was designed to evaluate the usefulness of PDU in the detection of prostate cancer. The diagnostic efficacy of PDU-guided target biopsy was compared with that of systematic sextant biopsy, and the clinicopathological features of PDU-negative cancer were compared with those of PDU-positive cancer.

Patients and Methods

From January 1998 through March 2000, 302 consecutive men, aged 45 to 94 years (mean age, 70 years), suspected to have prostate cancer on the basis of elevated serum levels of prostate-specific antigen (PSA>4 ng/m*l*; Tandem R assay; Hybritech Inc., San Diego, CA), abnormal digital rectal examination (DRE), or echogenic abnormalities on TRUS underwent 6 systematic sextant biopsies and PDU-guided target biopsy.

A single experienced urologist (G.K.) re-evaluated DRE, TRUS, and PDU immediately before biopsy. PDU examinations and biopsies were performed with the patient in the lithotomy position using a PDU system (SSA-340A; Toshiba Medical Systems), with a 6-MHz end-firing transrectal probe (PVL-625 RT; Toshiba Medical Systems, Tokyo, Japan), and an automatic biopsy gun mounted with an 18-gauge core-biopsy needle (Bard, Covington, GA) under intravenous sedation (propofol; AstraZeneca, London, UK). Power Doppler gain was set so that background noise disappeared in air. For the biopsy, the prostate was imaged in the transverse plane. The PDU-guided target biopsies were directed to both PDU-positive lesions, which were defined as areas with asymmetrically increased blood flow signals which exhibit any echogenicity (**Fig. 1**), and abnormal echogenic lesions without blood flow signals, except for simple cysts or stones. Specimens of specific lesions were obtained at target biopsy before systematic sextant biopsy, which was performed according to the method of Stamey (so called lateral-lobar biopsy)[13]. One to 3 cores (mean, 2 cores) were obtained from each specific lesion. In cases without echogenic abnormalities on PDU, only 6 systematic sextant biopsies were carried out.

Cases with positive biopsies were divided into 9 groups: T0: sextant biopsy was positive, but target biopsy was negative; S0: all sextant biopsies were

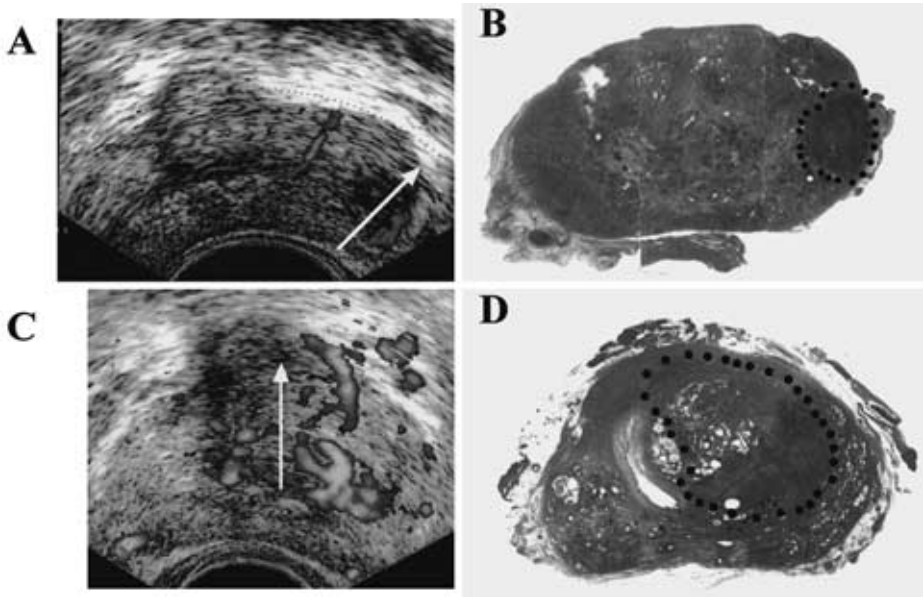

Fig. 1 Power Doppler imaging of prostate cancer and corresponding histologic sections. (A) A case of early-stage peripheral zone cancer (PSA, 11 ng/ml; Gleason score, 6; T2a). A hypoechoic nodule with increased power Doppler flow signals is located in the left lateral aspect of the peripheral zone. The arrow indicates the direction of target biopsy. (B) Corresponding histologic section of Fig. 1**A**. The dotted circle indicates the tumor location. (C) A case of transition zone cancer (PSA, 30 ng/ml; Gleason score, 7; T2b). An isoechoic nodule with asymmetrically increased power Doppler flow signals occupies the left transition zone. The arrow indicates the direction of target biopsy. (D) Corresponding whole-mount histologic section of Fig. 1**C**. The dotted circle indicates the tumor location.

negative, but target biopsy was positive; S1～S6: both sextant biopsy and target biopsy were positive (number indicates number of positive sextant biopsy); and Tx: sextant biopsy was positive, but no target biopsy was performed owing to a lack of echogenic abnormalities.

To identify the clinicopathological features of the cancer detected in each group the Gleason score (GS) and percentage organ confined disease (%OCD), calculated according to Partin's nomogram, 1997[14], were determined. In the present study, T3b, T3c, and T4 cancers were assigned to T3a for calculation of %OCD.

The Mann-Whitney U test was used to test for significant differences between the groups. Spearman's rank correlation was performed to test for significance of the correlation between the number of positive biopsies and GS or %OCD. The chi-square test was used to test for significant differences in sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy between PDU and other diagnostic methods. A p-value of <0.05 was defined as indicating statistical significance.

Table 1 Correlation between PSA and positive biopsy rate

PSA (ng/ml)	n	cancer-positive	(%)
0～4	30	6	(20.0)
4.1～10	119	35	(29.4)
10.1～20	62	24	(38.7)
20.1～30	21	12	(57.1)
30.1～40	16	12	(75.0)
＞40	54	54	(100)
total	302	143	(47.4)

Results

Cancer was detected in biopsy specimens from 143 cases (47.4%). **Table 1** shows the positive biopsy rate in each PSA range. The cancer-positive rate was 29.4% (35/119) in the gray zone, 20% (6/30) in

Table 2 Characteristics of prostate cancer patients according to DRE, TRUS, and PDU performed before biopsy

DRE	TRUS	PDU	all cases	gray zone cases
			n (%)	n (%)
neg.	neg.	neg.	8 (5.6)	4 (11.4)
neg.	neg.	pos.	2 (1.4)	1 (2.9)
neg.	pos.	pos.	39 (27.3)	19 (54.3)
pos.	neg.	pos.	3 (2.1)	2 (5.7)
pos.	pos.	pos.	91 (63.6)	9 (25.7)
			143 (100)	35 (100)

Table 3 Case number, GS, and % OCD in each group

group	case no. (%)	GS	%OCD
Tx	8 (5.6)	3.9	69.8
T0	6 (4.2)	5.3 *	40.2 *
S0	10 (7.0)	5.2 *	55.9
S1	13 (9.1)	5.2 *	52.1
S2	23 (16.1)	5.6 #	40.5 @
S3	19 (13.3)	6.1 #	27.2 **
S4	15 (10.5)	5.9 #	17.3 **
S5	14 (9.8)	6.4 #	5.7 ##
S6	35 (24.5)	7.7 $	2.9 $

$p < 0.05$, @ $p < 0.01$, # $p < 0.005$, ** $p < 0.001$, ## $p < 0.0005$, $ $p < 0.0001$ vs. Tx group (Mann-Whitney U test).

Positive biopsies were divided into 9 groups:

T0: sextant biopsy was positive, but target biopsy was negative

S0: all sextant biopsies were negative, but target biopsy was positive

S1 ～ S6: both sextant biopsy and target biopsy were positive (number indicates number of positive sextant biopsy).

For example S1 indicates sextant biopsy was positive in 1 biopsy and target biopsy was also positive, and S6 indicates sextant biopsy was positive in 6 biopsies and target biopsy was also positive.

Tx: sextant biopsy was positive, but no target biopsy performed owing to a lack of echogenic abnormalities

patients with a PSA level≤4.0 ng/m*l*, and 66.7% (102/153) in patients with a PSA level>10.0 ng/m*l*.

Table 2 shows the DRE, TRUS, and PDU characteristics of prostate cancer patients determined before biopsy. Ninety-one of 143 cancers (63.6%) had positive signs in all 3 tests, whereas 8 of 143 cancers (5.6%) had negative signs in all 3 tests. PDU indicated cancer in 135 of the 143 cases (94.4%). DRE-negative cancer occurred in 49 of 143 cases (34.3%). There were no cases in which cancer was suggested by TRUS but not by PDU, and PDU detected 5 of 13 TRUS-negative isoechoic cancers (38.5%).

In gray zone cases, 24 of 35 cancers (68.6%) were negative for DRE. PDU indicated cancer in 31 of 35 cases (88.6%) in the gray zone. PDU detected 3 of 7 TRUS-negative isoechoic cancers (42.9%).

Of the 143 biopsy-positive cases, 6 were in the T0 group (4.2%), 10 in the S0 group (7.0%), 119 in S1～S6 (83.2%), and 8 in Tx (5.6%). Overall, sextant biopsy missed 10 cases (S0), and target biopsy missed 14 (T0+Tx) (**Table 3**). The average GS and %OCD were 5.3 and 40.2% in T0, 5.2 and 55.9% in S0, 5.2 and 52.1% in S1, 5.6 and 40.5% in S2, 6.1 and 27.2% in S3, 5.9 and 17.3% in S4, 6.4 and 5.7% in S5, 7.7 and 2.9% in S6, and 3.9 and 69.8% in Tx. The GS was positively correlated with the number of positive biopsies ($rs = 0.541$, $p < 0.001$), and %OCD was negatively correlated ($rs = -0.698$, $p < 0.001$). The average GS of the Tx group was significantly lower than that of the other groups. The %OCD of the Tx group was significantly higher than that of the other groups except for the S0 ($p = 0.1347$) and S1 groups ($p = 0.1123$).

Of 159 patients with negative biopsies, 36 received transurethral resection of the prostate (TUR-P) for the treatment of dysuria after biopsy. Of these 36 patients, 14 received new diagnosis of cancer. All cases were DRE-negative with a PSA range of 2.4～28 ng/m*l* (average 9.8 ng/m*l*). Twelve cases were T1a and 2 cases were T1b according to the 1997 TNM classification. The average GS and %OCD of the Tx group were similar to those of the prostate cancer cases detected with TUR-P (3.6 and 66.1%).

Table 4 Values of diagnostic indexes for DRE, TRUS, and PDU

	all cases	n = 302			
	sensitivity (%)	specificity (%)	PPV (%)	NPV (%)	accuracy (%)
DRE	94/143 (65.7) $	131/159 (82.4)	94/122 (77.0)	131/180 (72.8) ##	225/302 (74.5)
TRUS	124/143 (86.7)	97/159 (61.0) #	124/186 (66.7) *	97/116 (83.6)	221/302 (73.2)
PDU	129/143 (90.2)	123/159 (77.4)	129/165 (78.2)	123/137 (89.8)	252/302 (83.4)
	gray zone cases	n = 119			
	sensitivity (%)	specificity (%)	PPV (%)	NPV (%)	accuracy (%)
DRE	11/35 (31.4) $	70/84 (83.3)	11/25 (44.0)	70/94 (74.5) @	81/119 (68.1)
TRUS	26/35 (74.3)	54/84 (64.3)	26/56 (46.4)	54/63 (85.7)	80/119 (67.2)
PDU	29/35 (82.9)	63/84 (75.0)	29/50 (58.0)	63/69 (91.3)	92/119 (77.3)

$p < 0.05$, @ $p < 0.01$, # $p < 0.005$, ## $p < 0.0005$, $ $p < 0.0001$
vs. PDU (chi-square test)

In the Tx group, all cases were negative for DRE, TRUS, or PDU and the GS was ≤4 in 7 of 8 cases. Only 2 positive core was obtained in each of 6 of these 7 cases.

Table 4 summarizes the sensitivity, specificity, PPV, NPV and accuracy of DRE, TRUS, and PDU. Overall, the sensitivity of PDU was 90.2% (129/143 cases), the specificity was 77.4% (123/159 cases), PPV was 78.2% (129/165 cases), NPV was 89.8% (123/137 cases), and accuracy was 83.4% (252/302 cases). PDU had the highest values of the 3 methods, except that of DRE had the highest specificity. The sensitivity and NPV of PDU were significantly higher than those of DRE ($p<0.0001$ and $p<0.0005$, respectively). The specificity and PPV of PDU were significantly higher than those of TRUS ($p<0.005$ and $p<0.05$, respectively). The specificity (64.3%) and accuracy (67.2%) of TRUS were the lowest of the 3 methods. Although PDU examined before biopsy suggested cancer lesions in 135 of 143 cases, PDU-guided target biopsy of PDU-positive lesions was negative for cancer in 6 of these 135 cases (T0 group), which resulted in a decrease in the sensitivity from 94.4% (135/143) to 90.2% (129/143 cases).

In all 6 cases in the T0 group both TRUS and PDU revealed abnormal lesions in the peripheral zone, and in 4 of 6 cases there were palpable nodules whose locations were consistent with the sites of PDU-guided target biopsy and adjacent to the cancer-positive sites detected by sextant biopsy. In these 6 cases, histological findings were high-grade prostaic intraepithelial neoplasia in 4, atypical glands in 1 and inflammation in 1. Three cases were clinical stage T3, and 3 were stage T2. These results suggest that false-negative biopsy results in 4 cases of the T0 group were due to sampling errors.

In gray zone cases the sensitivity, specificity, PPV, NPV, and accuracy of PDU were 82.9%, 75.0%, 58.0%, 91.3%, and 77.3%, respectively. Again, each value of PDU was the highest of the 3 methods, except for the specificity of DRE. The sensitivity and NPV of PDU were significantly higher than those of DRE ($p<0.0001$ and $p<0.01$, respectively). The specificity (64.3%) and accuracy (67.2%) of TRUS were the lowest of the 3 methods.

Discussion

Current imaging techniques have been reported to be insufficient for detecting localized early prostate cancer. For this reason the prostate gland is the only organ in which histological confirmation of cancer has been carried out in a systematic manner rather than a lesion-directed manner, since the study of Hodge et al.[1] who described systematic sextant biopsy in 1989.

Controversy about of gray-scale TRUS in the diagnosis of prostate cancer has been attributed to the lack of sensitivity and specificity of this method. Although a hypoechoic lesion in the peripheral zone is the most common appearance of prostate cancer, it is not specific, and lesions, including inflammation, infarction, and fibrosis, also appear hypoechoic,

Table 5 Case number in each group according to DRE positivity

	DRE (+)	DRE (−)
Group	case no. (%)	case no. (%)
Tx	0 (0)	8 (16.3)
T0	4 (4.3)	2 (4.1)
S0	2 (2.1)	8 (16.3)
S1	5 (5.3)	8 (16.3)
S2	12 (12.8)	11 (22.4)
S3	14 (14.9)	5 (10.2)
S4	12 (12.8)	3 (6.1)
S5	14 (14.9)	0 (0)
S6	31 (33.0)	4 (8.2)
S1 ～ 6	88 (93.6)	31 (63.3)
TOTAL	94 (100)	49 (100)

resulting in low specificity[2]. Moreover, TRUS cannot detect isoechoic cancer[2]. In an attempt to overcome these problems, PDU was evaluated for the detection of prostate cancer in the present study. In general, cancer growth is faster and requires a greater blood supply than does normal tissue, resulting in an increased number of blood vessels in tumor tissue due to tumor angiogenesis. PDU can detect the fine blood flow of these tumor vessels with high sensitivity[12], so that PDU might be used to identify cancer lesions that are not detected with TRUS.

In our study, of 94 cases of DRE-positive cancer, in which PDU recognized blood flow-positive nodules, 92 were detected with sextant biopsy (97.9%; four T0+88 S1～S6 groups) and 2 with target biopsy alone (2.1%; S0 group). Target biopsy missed cancer in 4 cases (4.2%; T0 group) (**Table 5**). Concerning these 4 cases, a retrospective analysis found that the sites of palpable nodules were consistent with the sites of PDU-positive lesions where target biopsies were performed. Moreover, these sites were consistent with the cancer-positive sites detected with sextant biopsy. These results suggest that in the T0 group PDU correctly detected DRE-positive cancer nodules; however, unfortunately target biopsy failed in obtaining cancer because of technical failure. Therefore, it is suggested that in almost all cases of DRE-positive cancer both the sextant and target biopsies were able to obtain cancer tissue accurately.

In contrast, among 49 cases of DRE-negative cancer, 8 (16.3%; S0) were missed with sextant biopsy and were detected with target biopsy alone (**Table 5**). However, target biopsy also missed 10 cases (20.4%; 2 T0 and 8 Tx). These results suggest that in DRE-negative cancer neither sextant nor target biopsy is sufficient to obtain cancer tissue accurately. The use of PDU-guided target biopsy as an adjunct to sextant biopsy increased the positivity rate in DRE-negative cancer to 16.3% (8/49). Both biopsy methods may be necessary in DRE-negative cancer to reduce error in sampling cancer tissue.

In this study, the overall sensitivity of PDU was 90.2%, the specificity was 77.4%, PPV was 78.2%, NPV was 89.8% and accuracy was 83.4%. These results are comparable to those of recent PDU studies, including those of Sakarya et al.[8], Okihara et al.[9], Franco et al.[10], and Takahashi et al.[11], as shown in **Table 6**. The differences in the sensitivity and specificity between studies were thought to be due mainly to differences in the cut-off intensity of the power Doppler flow signals considered positive. In this study, as well as in the studies of Sakarya et al., Okihara et al., and Takahashi et al., slight flow was considered positive, whereas Franco et al. considered slight flow to be negative. In all of these studies both the sensitivity and specificity of PDU were higher than those of TRUS, which suggests that PDU detects prostate cancer at a higher rate than does TRUS, without an increase in false-positive cases. It is suggested that PDU should be used instead of conventional TRUS for the detection and targeting of prostate cancer to improve diagnostic efficacy.

Previous studies have documented that prostate cancer with increased color Doppler flow has a significantly higher GS than does CDU-negative cancer[15–19]. Furthermore, Ismail et al. have reported that prostate cancer with marked discrete color Doppler signals has higher rates of seminal vesicle invasion, non-organ confined disease, and relapse following radical prostatectomy[16]. In contrast to CDU, there have been few studies examining the relation between tumor aggressiveness and the strength of power Doppler flow. Okihara et al.[9] and

Table 6 Values of diagnostic indexes for PDU in previously reported studies

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Sakarya et al.[8]	90	75	82	88
Okihara et al.[9]	98	78	59	99
Franco et al.[10]	74	96	74	96
Takahashi et al.[11]	90	90	84	94
Present study	90.2	77.4	78.2	89.8

Takahashi et al.[11] have reported that no significant difference in GS between cancers with low and high PDU grades; however, they did not compare the GS between PDU-invisible and PDU-visible cancers. In the present study, the clinicopathological features of cancer cases were analyzed by determining the GS and %OCD according to Partin's nomogram as indicators of tumor aggressiveness in each group. The GS of PDU-invisible cancer (Tx group) was found to be≤4 in 7 of 8 cases, with a mean of 3.9, which was significantly lower than that of the other groups. Of the 7 cases with a GS of ≤4, 6 cases had 1 positive core and 1 case had 2 positive cores. The %OCD of the Tx group was 69.8%, which was higher than that of the other groups. The average GS and %OCD of the Tx group were similar to those of the prostate cancer cases detected with TUR-P (3.6 and 66.1%, respectively) after confirmation of negative biopsy. These results suggest, although the strength of power Doppler flow signals was not graded, that PDU-invisible cancer has a less aggressive biological nature and appears to have a good prognosis. Although additional studies are needed, PDU-negative cancer is most likely a specific entity, such as stage A prostate cancer.

Conclusions

PDU in association with sextant biopsy is a useful tool for increasing the rate of detection of prostate cancer. Further advances in ultrasound technology may enable the detection of prostate cancer with target biopsy alone and, consequently, may reduce the number of unnecessary biopsies. However, PDU-guided target biopsy alone is insufficient for cancer detection at the present time because of possible technical failure in obtaining specimens and the existence of PDU-negative cancer. Although more evidence is required, PDU-negative cancer is suggested to be less aggressive clinically, possibly justifying a watch and wait policy.

References

1. Hodge KK, McNeal JE, Terris MK, Stamey TA: Random systematic versus directed ultrasound guided transrectal core biopsies of the prostate. J Urol 1989; 142: 71–75.
2. Rifkin MD: Ultrasound in the evaluation of prostate cancer. In Ultrasound of the prostate: imaging in the diagnosis and therapy of prostatic disease, 2 nd edn. Chapt 13, 1997; pp 191–217, Lippincott-Raven Press, Philadelphia.
3. Rifkin MD, Sudakoff GS, Alexander AA: Prostate, techniques, results, and potential applications of color Doppler US scanning. Radiology 1993; 186: 509–513.
4. Kelly IMG, Lees WR, Rickards D: Prostate cancer and the role of color Doppler US. Radiology 1993; 189: 153–156.
5. Newman JS, Bree RL, Rubin JM: Prostate cancer: diagnosis with color Doppler sonography with histologic correlation of each biopsy site. Radiology 1995; 195: 86–90.
6. Sauvain JL, Palascak P, Bremon JM: Power Doppler ultrasonography and hypoechoic nodules of the peripheral prostate: perspectives and limitations. J Radiol 1997; 78: 491–497.
7. Cho JY, Kim SH, Lee SE: Diffuse prostatic lesions: role of color Doppler and power Doppler ultrasonography. J Ultrasound Med 1998; 17: 283–287.
8. Sakarya ME, Arslan H, Unal O, Atilla MK, Aydin S: The role of power Doppler ultrasonography in the diagnosis of prostate cancer: a preliminary study. BJU International 1998; 82: 386–388.
9. Okihara K, Kojima M, Nakanouchi T, Okada K, Miki T: Transrectal power Doppler imaging in the detection of prostate cancer. BJU International 2000; 85: 1053–1057.
10. Franco OE, Arima K, Yanagawa M, Kawamura J: The usefulness of power Doppler ultrasonography for diagnosing prostate cancer: histological

correlation of each biopsy site. BJU International 2000; 85: 1049–1052.
11. Takahashi S, Yamada Y, Homma Y, Horie S, Hosaka Y, Kitamura T: Power Doppler ultrasonography-directed prostate biopsy in men with elevated serum PSA levels: An evaluation of the clinical utility and limitations. Urology 2002; 60: 248–252.
12. Rubin JM, Bude RO, Carson PL, Bree RL, Adler RS: Power Doppler US: a potentially useful alternative to mean frequency-based color Doppler US. Radiology 1994; 190: 853–856.
13. Stamey TA: Making the most out of six systematic sextant biopsies. Urology 1995; 45: 2–12.
14. Partin AW, Kattan MW, Subong ENP, Walsh PC, Wojno KJ, Oesterling JE, Scardino PT, Pearson JD: Combination of prostate-specific antigen, clinical stage, and Gleason score to predict pathological stage of localized prostate cancer. J Am Med Assoc 1997; 277: 1445–1451.
15. Cornud F, Belin X, Piron Y, Chretien Y, Flam T, Casanova JM, Helenon O, Mejean A, Thiounn N, Moreau JF: Color Doppler-guided prostate biopsies in 591 patients with an elevated serum PSA level: impact on Gleason score for nonpalpable lesions. Urology 1997; 49: 709–715.
16. 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: 906–912.
17. Lavoipierre AM, Snow RM, Frydenberg M, Gunter D, Reisner G, Royce PL, Lavoipierre GJ: Prostatic cancer: role of color Doppler imaging in transrectal sonography. AJR 1998; 171: 205–210.
18. Louvar E, Littrup PJ, Goldstein A, Yu L, Sakr W, Grignon D: Correlation of color Doppler flow in the prostate with tissue microvascularity. Cancer 1998; 83: 135–140.
19. Kuligowska E, Barish MA, Fenlon HM, Blake M: Predictors of prostate carcinoma: Accuracy of gray-scale and color Doppler US and serum markers. Radiology 2001; 220: 757–764.

(Received, May 26, 2005)
(Accepted, July 13, 2005)