ELSEVIER *Original Article*

Role of Colour Doppler Imaging in Detecting Prostate Cancer

Jyotsna Sen, Lalita Choudhary, Sanjay Marwah,[1] Rajesh Godara,[1] Nisha Marwah[2] and Rajiv Sen,[2]
Departments of Radiodiagnosis, [1]Surgery and [2]Pathology, Postgraduate Institute of Medical Sciences, Rohtak, Haryana, India.

OBJECTIVE: This prospective study was undertaken to evaluate the role of colour Doppler sonography in the assessment of prostate carcinoma.
METHODS: Forty consecutive patients who were suspected of having prostate carcinoma with either raised prostate specific antigen or abnormal digital rectal examination were included in the study. Transrectal greyscale and colour Doppler sonography of the prostate was performed using a 5–9 MHz intracavitary probe. Needle biopsies were taken from areas that showed increased flow on colour Doppler. The results were correlated with the final diagnosis established on histopathological examination.
RESULTS: Comparison of greyscale and colour Doppler sonography showed that the latter is more sensitive and specific in predicting the malignancy. The statistical parameters of colour Doppler versus greyscale sonography were: sensitivity 88.23 *vs.* 73.52, specificity 66.66 *vs.* 33.33, positive predictive value 93.75 *vs.* 85.18, and negative predictive value 50 *vs.* 22.22, respectively.
CONCLUSION: Colour Doppler and greyscale sonography should be routinely performed to improve detection of prostate carcinoma and to target the lesion. [*Asian J Surg* 2008;31(1):16–9]

Key Words: prostate cancer, sonography

Introduction

The prostate gland is the site of two common diseases in the ageing man, benign prostatic hyperplasia and prostate cancer. The latter is the sixth most common malignancy in males over the age of 55 and the second most common cause of death.[1] Clinically, the malignancy is suspected on abnormal digital rectal examination (DRE) or raised prostate specific antigen (PSA) levels, but DRE is subjective. PSA alone has poor sensitivity and specificity in predicting malignancy, particularly in patients with PSA < 20 ng/mL. Transrectal sonography provides high resolution images of the prostate. Colour Doppler further helps in the evaluation of blood flow through prostatic vessels and has been described as a means of differentiating malignancy from benign hyperplasia as microvessel density is higher in the former. This study evaluated the role of colour Doppler in the assessment of prostate carcinoma.

Materials and methods

This prospective study included 40 consecutive patients who were suspected of having prostate carcinoma with either raised PSA (> 4 ng/mL) or abnormal DRE. First, transrectal greyscale sonography was performed with the patient in the left lateral position, using a broadband 5–9 MHz intracavitary probe after covering it with a protective rubber sheath (condom). Greyscale scanning was done from the base to the apex of the prostate, as well as surrounding structures such as the seminal vesicles, urethra

Address correspondence and reprint requests to Dr Rajesh Godara, 58/9J, Medical Enclave, Rohtak, Haryana 124001, India.
E-mail: drrajeshgodara@yahoo.co.uk • Date of acceptance: 14 June 2007

and rectum to look for areas that appeared suspicious. This was followed by colour Doppler to assess the flow, through the entire prostate and suspicious foci. The flow signals from colour Doppler were evaluated and categorized into three groups relative to surrounding tissue: increased, equal, or decreased. Peak systolic velocity (S), end-diastolic velocity (D) and resistance index (RI) were also calculated: R1 = S – D/S.

Transrectal ultrasound-guided needle biopsies were performed to obtain two satisfactory core samples using a core tissue biopsy needle (18-G, 16 cm) from areas that showed increased flow on colour Doppler in 32 patients (greyscale sonography showed areas of altered echotexture in 22 patients and homogeneous echotexture in 10 patients). Repeat four quadrant biopsies were done in two patients who had increased flow signals, and biopsies were negative for malignancy. All eight patients with equivocal flow and decreased flow signals were subjected to core needle random quadrant biopsies. As per the standard practice of our institute, prophylactic antibiotics were not given.

Ultrasound results were correlated with the final diagnoses established by histopathological examinations.

Results

Prostate carcinoma was proved in 34 (85%) patients and benign prostatic disease in six (15%) on the basis of histopathological examination. Carcinoma was found in 23 of 29 patients with abnormal DRE; in 11 patients with malignant disease, DRE had been normal. Of the 39 patients with PSA > 4 ng/mL, 34 had carcinoma and five had benign disease on pathological examination. PSA levels in patients with carcinoma varied from 5.5 to 218 ng/mL. The mean PSA level in patients with carcinoma was 53 ng/mL, compared to 9.6 ng/mL in patients with benign disease.

According to transrectal greyscale ultrasound alone, benign prostatic disease was suspected in 16 patients because of the homogeneous echotexture of the prostate without any features of invasion in the surrounding structures in 14 patients and an isoechoic nodule in the central zone in two patients. Twelve of the 14 and one of the two were later diagnosed with carcinoma according to histopathology. Hypoechoic nodules (mean size, 9 mm; range, 2–24 mm) in the peripheral zone in 21 patients and a heterogeneous echotexture of the prostate in three patients were considered to be suggestive of malignancy on transrectal ultrasound; 19 of the 21 patients and two of the three were later shown to have periprostatic invasion that was positive for carcinoma on biopsy.

On transrectal colour Doppler sonography, the presence of increased flow signals were considered positive for malignancy in 32 patients (30 biopsies proved). Decreased or equivocal flow signals were considered indicative of benign disease in eight patients (4 turned out to be malignant on biopsy). The spectral analysis of increased flow signals showed peak systolic velocity ranging from 1.32 cm/s to 59 cm/s and end-diastolic velocity ranging from 0.9 cm/s to 27.5 cm/s. In cases with equal or decreased flow, peak systolic velocity ranged from 10.4 cm/s to 32.5 cm/s and end-diastolic velocity ranged from 2.1 cm/s to 7.2 cm/s. Mean RI in the former spectrum was 0.73 and in the latter was 0.79. The difference in the mean RI between the two groups was not statistically significant. Table 1 shows concordance of greyscale and Doppler sonography findings with histopathology in relation to PSA levels.

Complications after transrectal ultrasound-guided biopsy occurred in one patient in the form of haematuria of 1 day's duration, which did not require any treatment. Although prophylactic antibiotics were not given, follow-up urine examination of all patients 1 week later did not show any pyuria. The comparison of greyscale transrectal sonography and colour Doppler sonography with histopathological diagnosis (Table 2) showed that colour Doppler sonography is more sensitive and specific in predicting prostate malignancy. The statistical parameters of colour Doppler versus greyscale sonography are sensitivity 88.23 *vs.* 73.52, specificity 66.66 *vs.* 33.33, positive predictive value 93.75 *vs.* 85.18, and negative predictive value 50 *vs.* 22.22, respectively. The concordance of greyscale and Doppler studies with histopathological diagnosis including both benign and malignant lesions was 25/40 (62.5%) and 34/40 (85%), respectively.

Discussion

In the present study, greyscale and colour Doppler sonography using intracavitary probe via a transrectal route was evaluated for picking up malignancy in the prostate after abnormal DRE and elevated PSA levels. On transrectal greyscale sonography, hypoechoic areas in the peripheral zone, heterogeneous echotexture and features suggestive of invasion of the capsule and periprostatic tissues were found to be useful predictors of malignancy. It must be kept

Table 1. Comparison of final histopathology, greyscale and colour Doppler sonographic features

Greyscale ($n = 40$)	Colour Doppler	
	Increased flow	Equivocal/Decreased flow
Benign (16)		
Homogeneous echotexture (14)	10 (Ca, 8; B, 2)	4 (all Ca)
Isoechoic nodules in central zone (2)	1 (Ca, 1)	1 (B, 1)
Carcinoma (24)		
Heterogeneous echotexture (3)	2 (Ca, 2)	1 (B, 1)
Hypoechoic nodules in peripheral zone (21)	19 (Ca, 19)	2 (B, 2)

Ca = carcinoma; B = benign.

Table 2. Concordance of greyscale and Doppler sonography studies with histopathology and prostate specific antigen (PSA) levels

PSA, mg	Patients, *n*	Greyscale	Doppler
0–4	1 B	1	1
> 4–10	2 B	1	1
	3 Ca	1	3
> 10–20	3 B	1	2
	5 Ca	3	4
> 20	26 Ca	18	23

Ca = carcinoma; B = benign.

in mind that all peripheral nodules need not always be malignant, as in two cases in the present study.

The incidence of carcinoma appearing as hypoechoic nodules in the present series (55.88%) is similar to other studies that reported that more than 50% of carcinomas are hypoechoic.[2–4] The incidence of carcinoma with heterogeneous echotexture in this study (6%) is at the lower end of the reported range for such lesions (2–20%).[2,3,5]

Normal homogeneous echotexture was seen in 35.2% of cases of prostate carcinoma, which is comparable to the reported range of 24–32%.[6] The incidence of isoechoic nodule (1 in this study) and hyperechoic nodule (none in this study) turning out to be malignant is very low.[3,5,7] Subtle hyperechoic areas must be differentiated from highly echogenic prostatic calculi and corpora amylacea.[3] The echogenicity in carcinoma has been reported to be variable and is co-related with stromal fibrosis/desmoplasia.[4] The histological grade of the carcinoma may modify the echogenicity.

Transrectal colour Doppler sonography showed increased flow signals in 32 patients; carcinoma was proved on biopsy in 30 (88.24%). The reported range of increased flow signals in prostate malignancy varies from 77% to 100%.[4,7–9] Tumour angiogenesis causes increased vasculature, which results in increased flow signals. It has been suggested that hypervascularity even without focal greyscale abnormality is highly suspicious and must be subjected to biopsy.[10] In the present study, eight cases of carcinoma were suspected on colour Doppler imaging only as greyscale ultrasound had shown a normal homogeneous echo pattern. Similar patterns have been reported by others.[9,10]

Although quite sensitive, colour Doppler studies do have limitations. Inflammation enhances blood flow through the prostate.[11] In contrast, desmoplastic reactions obliterate tumour vasculature in carcinoma. In the present study, four cases did not show increased flow signals, and three of these demonstrated desmoplastic reaction on histology. A similar incidence of decreased flow signals in malignancy has been reported by Cho et al.[12] Benign cases with increased flow signals but with homogeneous echo pattern on greyscale ultrasound were demonstrated to be nonspecific prostatitis and nodular hyperplasia on histopathology. In this study, there was no statistically significant difference in mean RI between the benign and prostate carcinoma groups (0.79 and 0.73, respectively). Similar results have been reported by others.[4,8] An attempt was made in the present study to compare greyscale and Doppler findings in relation to PSA levels and pathological diagnoses. Although the sample size was small, the observations suggest that PSA > 20 mg invariably indicates malignancy irrespective of greyscale and Doppler sonographic findings. Doppler sonography picked up malignancy in 23 of 26 (88.46%) compared to 18 of 26 (69.23%) on greyscale sonography.

For transrectal greyscale ultrasound, the sensitivity and specificity of 73.52% and 33.33% are comparable

to Kelly et al's figures of 75% and 49%, respectively.[8] The addition of colour Doppler improved the sensitivity and specificity to 83.33% and 66.66%, respectively, in the present study, which is almost the same as reported by others.[11,13] The 85% concordance of colour Doppler studies with histopathological diagnosis is much higher than the 62.5% concordance of greyscale sonographic findings with histopathological findings.

In this study, ultrasound-guided transrectal biopsy of the prostate was done without analgesia, anaesthesia or prophylactic antibiotics. The complication rate of 2.5% was negligible and the same as the 2.5% reported by Rifkin and Choi.[14]

Colour Doppler sonography should be routinely performed together with greyscale transrectal sonography of the prostate gland to improve detection and targeting of lesions in prostate carcinoma. We further recommend that even if negative findings are noted on both greyscale and colour Doppler sonography, ultrasound-guided transrectal biopsy be performed to rule out prostatic malignancy in patients with PSA > 4 mg.

References

1. Lee F Jr, Bronson JP, Lee F, et al. Nonpalpable cancer of the prostate: assessment with transrectal US. *Radiology* 1991;178:197–9.
2. Burks DD, Drolshagen LF, Fleischer AC, et al. Transrectal sonography of benign and malignant prostatic lesions. *AJR Am J Roentgenol* 1986;146:1187–91.
3. Rifkin MD, McGlynn ET, Choi H. Echogenicity of prostate cancer correlated with histologic grade and stromal fibrosis: endorectal US studies. *Radiology* 1989;170:549–52.
4. Shigeno K, Igawa M, Shiina H, et al. The role of colour Doppler ultrasonography in detecting prostate cancer. *BJU Int* 2000; 86:229–33.
5. Cooner WH, Mosley BR, Rutherford CL Jr, et al. Prostate cancer detection in a clinical urological practice by ultrasonography, digital rectal examination and prostate specific antigen. *J Urol* 1990;143:1146–54.
6. Dahnert WF, Hamper UM, Eggleston JC, et al. Prostatic evaluation by transrectal sonography with histopathologic correlation: the echopenic appearance of early carcinoma. *Radiology* 1986;158: 97–102.
7. Barish MA, Pomeroy O, Fenion HM, et al. Accuracy of greyscale versus color Doppler transrectal ultrasound (TRUS) in detection of prostate cancer. *Eur Clin Radiol* 1999;4:56–7.
8. Kelly IM, Lees WR, Rickards D. Prostate cancer and the role of Doppler US. *Radiology* 1993;189:153–6.
9. Halpern EJ, Strup SE. Using gray-scale and color and power Doppler sonography to detect prostatic cancer. *AJR Am J Roentgenol* 2000;174:623–7.
10. Neumaier CE, Martinoli C, Derchi LE, et al. Normal prostate gland: examination with color Doppler US. *Radiology* 1995;196: 453–7.
11. Gregori A, Vieweg J, Dahm P, Paulson DF. Comparison of ultrasound-guided biopsies and prostatectomy specimens: predictive accuracy of Gleason score and tumor site. *Urol Int* 2001; 66:66–71.
12. Cho JY, Kim SH, Lee SE. Peripheral hypoechoic lesions of the prostate: evaluation with color and power Doppler ultrasound. *Eur Urol* 2000;37:443–8.
13. Aarnink RG, Beerlage HP, De La Rosette JJ, et al. Transrectal ultrasound of the prostate: innovations and future applications. *J Urol* 1998;159:1568–79.
14. Rifkin MD, Choi H. Implications of small, peripheral hypoechoic lesions in endorectal US of the prostate. *Radiology* 1988;166: 619–22.