

Differentiation of prostate cancer and benign prostatic hyperplasia: the clinical value of ^{201}Tl SPECT—a pilot study

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Purpose: Thallium-201 (^{201}Tl) is a recognized tumor-imaging agent; however, the usefulness of ^{201}Tl in prostate cancer has not been studied. The purpose of this preliminary study was to evaluate the efficacy of ^{201}Tl single-photon emission computed tomography (SPECT) imaging for differentiating prostate cancer from benign prostatic hyperplasia (BPH). **Methods:** ^{201}Tl pelvic SPECT was performed in 10 patients (aged 64–78 years) with biopsy-proven BPH before transurethral resection of the prostate and 15 patients (aged 65–81 years) with biopsy-proven prostate cancer prior to any therapeutic modality or invasive surgical procedures for treatment of their prostate cancer. **Results:** From the 15 patients with prostate cancer, ^{201}Tl pelvic SPECT detected prostate cancer in 13 (86.7%) but not in 2 (13.3%) patients with Gleason scores of 5 (2 + 3). In contrast, all 10 patients with BPH (100.0%) had negative results of ^{201}Tl pelvic SPECT. **Conclusion:** Our study showed that ^{201}Tl pelvic SPECT scan is very helpful in distinguishing between prostate cancer and BPH.

Key words: prostate cancer, benign prostatic hyperplasia, ^{201}Tl SPECT

INTRODUCTION

PROSTATE CANCER is the most common malignancy in men in many countries.¹ Adenocarcinoma is a major type of all primary prostatic cancer. Benign prostatic hyperplasia (BPH) is a common disorder characterized clinically by enlargement of the prostate, with obstruction to the flow of urine through the bladder outlet.² Early differential diagnosis between prostate cancer and BPH is very important because both the outcome and treatment of these two prostatic diseases are distinct. A variety of clinical procedures, such as digital rectal examination and radioimmunoassays for prostate specific antigen (PSA) have proved to have acceptable sensitivities and specificities for screening studies. But they can not offer absolute results for the differentiation of prostate cancer and BPH. The role of PSA is mainly to detect recurrence during follow-up by a

rising serum PSA level.³ In addition, many imaging methods such as ultrasonography, CT, MRI are available for the diagnosis and management of prostate cancer.⁴ 18-fluoro-2-deoxyglucose (FDG) positron emission tomography (PET) has also been used in the evaluation of prostate cancer.^{5–7} But overall PET imaging in prostate cancer has produced disappointing results because there is a significant overlap in uptake values in prostate cancer and BPH. To image the prostate, bladder activity is a problem unless interventions are taken to eliminate urinary FDG activity. For most patients this entails adequate hydration and bladder irrigation with a Foley catheter. In addition, there are many theoretical and practical problems associated with its use in clinical imaging, such as high cost and poor availability.

Thallium-201 (^{201}Tl) is a monovalent cationic radioisotope with biological properties similar to those of potassium.^{8,9} ^{201}Tl has been used extensively in the evaluation of myocardial perfusion. Its use as a tumor-imaging agent was described in 1976, and many kinds of malignancies have been detected by ^{201}Tl .^{10–14} However, the feasibility of ^{201}Tl for the detection of prostate cancer has not been evaluated. Therefore, in this preliminary study,

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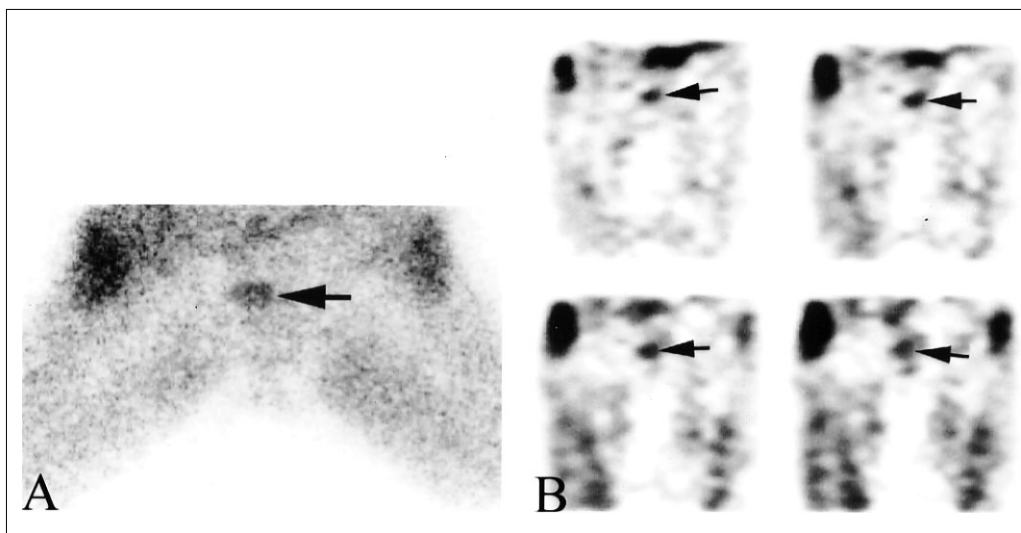


Fig. 1 The 74-year-old male (case 7) is a patient with prostate cancer. The ^{201}Tl planar view of pelvis (A) and pelvic SPECT (B) (coronal slices) reveal abnormally focal increased ^{201}Tl uptake in the prostate region (arrows).

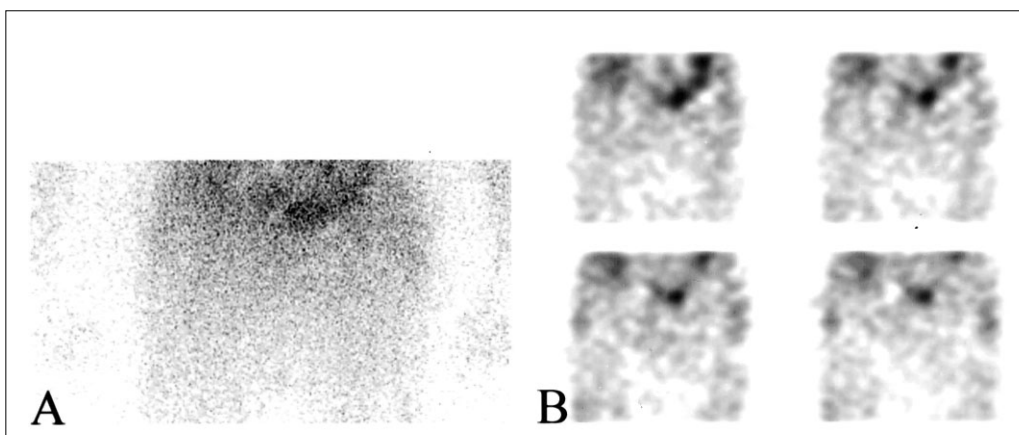


Fig. 2 The 77-year-old male (case 9) is a patient with BPH. The ^{201}Tl planar view of pelvis (A) and pelvic SPECT (B) (coronal slices) reveal no abnormal ^{201}Tl uptake in the prostate region.

we tried to evaluate the efficacy of ^{201}Tl pelvic single-photon emission computed tomography (SPECT) scan for differentiating prostate cancer from BPH.

MATERIALS AND METHODS

Patients

Ten patients (aged 64–78 years) with biopsy-proven BPH before transurethral resection of the prostate and 15 patients (aged 65–81 years) with biopsy-proven prostate cancer with negative bone scan before any therapeutic modality or invasive surgical procedures for treatment of their prostate cancer underwent ^{201}Tl pelvic SPECT scan. Systemic transrectal ultrasound-guided biopsies were performed by experienced urologists, obtaining at least six biopsies as described by Niesel et al.¹⁵ Gleason scores

of the prostate cancer ranged from 5 (2 + 3) to 10 (5 + 5). The serum concentration of PSA was measured in all patients.

^{201}Tl Pelvic SPECT Scan

The planar image of pelvis and pelvic SPECT scan were performed 20 minutes after IV injection of ^{201}Tl (74 MBq). The patient was positioned supine on the imaging table with the abdomen strapped in order to prevent motion. The SPECT data were obtained using a dual-headed gamma camera (ADAC, Vertex plus) equipped with a low energy, all-purpose, parallel-hole collimator. Data were collected from 64 projections over 360° (180° for each head) in 64 × 64 matrices, with an acquisition time of 35 sec/view. Reconstruction of the image was performed with attenuation correction using a Butterworth

Table 1 Detailed data of the patients with BPH

Patient No.	Age (years)	PSA (ng/ml)	Histology	²⁰¹ Tl SPECT of pelvis
1	65	7.2	BPH	N
2	68	6.7	BPH	N
3	72	9.8	BPH	N
4	75	8.5	BPH	N
5	78	13.8	BPH	N
6	69	17.0	BPH	N
7	72	8.8	BPH	N
8	64	5.7	BPH	N
9	77	10.2	BPH	N
10	74	14.1	BPH	N

PSA: prostate specific antigen

BPH: benign prostatic hyperplasia

N: negative

Table 2 Detailed data of the patients with prostate cancer

Case No.	Age (years)	PSA (ng/ml)	Histology/ Gleason score	²⁰¹ Tl SPECT of pelvis
1	65	12.1	Adenocarcinoma/6 (3 + 3)	P
2	71	9.5	Adenocarcinoma/5 (3 + 2)	P
3	73	7.5	Adenocarcinoma/5 (3 + 2)	P
4	78	13.8	Adenocarcinoma/7 (3 + 4)	P
5	69	11.2	Adenocarcinoma/5 (2 + 3)	N
6	80	15.2	Adenocarcinoma/7 (3 + 4)	P
7	74	7.1	Adenocarcinoma/6 (3 + 3)	P
8	68	5.9	Adenocarcinoma/5 (3 + 2)	P
9	72	9.8	Adenocarcinoma/5 (2 + 3)	N
10	78	17.9	Adenocarcinoma/9 (4 + 5)	P
11	75	22.7	Adenocarcinoma/10 (5 + 5)	P
12	81	5.5	Adenocarcinoma/5 (3 + 2)	P
13	68	9.2	Adenocarcinoma/7 (3 + 4)	P
14	76	14.7	Adenocarcinoma/5 (3 + 2)	P
15	77	16.2	Adenocarcinoma/6 (3 + 3)	P

PSA: prostate specific antigen

P: positive

N: negative

filter, and with a cutoff frequency of 0.35 per cm and an order of 5. All SPECT images were interpreted by agreement of at least two of three nuclear medicine physicians who were blind to the patients' clinical data. The results of ²⁰¹Tl SPECT were classified as positive (focal abnormal accumulation of ²⁰¹Tl at the prostate region) (Fig. 1) or negative (no abnormal uptake of ²⁰¹Tl at the prostate region) (Fig. 2).

RESULTS

The detailed data of patients and results of study are summarized in Tables 1 and 2. From the 15 patients with prostate cancer, ²⁰¹Tl pelvic SPECT detected prostate cancer in 13 (86.7%) but not in 2 (13.3%) patients with

Gleason score of 5 (2 + 3). In contrast, all 10 patients with BPH (100.0%) had negative results of ²⁰¹Tl pelvic SPECT. The ranges of PSA in prostate cancer and BPH were 5.5 ng/ml to 22.7 ng/ml and 5.7 ng/ml to 17.0 ng/ml, respectively. No scintigraphy-related discomfort or side-effects were observed in either group during the study.

DISCUSSION

²⁰¹Tl has been used since the 1970s to evaluate myocardial perfusion. There is now a growing and convincing amount of data to show that it can also play an important clinical role in tumor imaging.¹⁶⁻¹⁹ ²⁰¹Tl is thought to behave biologically like potassium^{8,9} and its similarity to alkali metals such as cesium, which concentrates in tumors, was one factor that to its evaluation for tumor imaging.⁸ Other possible factors of ²⁰¹Tl in tumor localization include blood flow, tumor viability, tumor type, the sodium-potassium ATPase system, the cotransport system, calcium ion channel exchange, vascular immaturity with leakage and increased cell membrane permeability²⁰⁻²⁵; however, the exact mechanism of tumor localization is unclear.

To the authors' knowledge, there are no reported studies that used ²⁰¹Tl to evaluate prostate cancer and BPH. ²⁰¹Tl has definite advantages being relatively inexpensive and widely available. It also has some disadvantages as an imaging method because of poor imaging characteristics, with poor imaging energies and a long physical and biologic half-life. However, the recent use of SPECT has improved the depiction and resolution of ²⁰¹Tl in detection of lesions compared to conventional planar image.²⁶ In the results of this study, ²⁰¹Tl pelvic SPECT scan could detect prostate cancer effectively. The false-negative results in 2 patients (case 5 and case 9) may have been due to relative well-differentiated tumors with Gleason score of 5 (2 + 3) than those of the others with Gleason score of 5 (3 + 2) to 10 (5 + 5). Prostatic adenocarcinoma is most commonly classified according to the Gleason grading system, which is based on five histological patterns of tumor gland formation and infiltration. Recognizing the high frequency of mixed tumor patterns, the Gleason score is the sum of the grade (1 to 5) attributed to the most prominent pattern and that of the minority pattern. The best-differentiated tumors have a Gleason score of 2 (1 + 1), whereas the most poorly differentiated cancers yield a Gleason score of 10 (5 + 5).²⁷ However, no significant relationship was found between PSA levels and SPECT results in this study.

In conclusion, our preliminary study demonstrated that ²⁰¹Tl pelvic SPECT scan is very helpful to distinguish between prostate cancer and BPH. In the future, we will increase the patient numbers in order to confirm the utility of ²⁰¹Tl pelvic SPECT scan in the detection of prostate cancer and to evaluate whether there is a statistically significant relationship between the ²⁰¹Tl pelvic SPECT

and different tumor type, size of tumor or cell differentiation.

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