Planar scintigraphy does not always detect migrated seeds after transperineal interstitial permanent prostate brachytherapy with 125I radioactive seeds

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Citation

Abstract
Purpose: The purpose is to report a limitation of the scintigraphic technique for detecting migrated seeds after prostate brachytherapy with 125I seeds.

Methods and Materials: Three patients with prostate cancer were chosen for the study. Patients underwent prostate brachytherapy with 125I seeds. Postimplant radiographs showed that all three patients exhibited seed migration. Patients were scanned in the supine position with a γ-camera.

Results:
Case 1: A postimplant pelvic radiograph showed a seed that had migrated to the pelvic area and that was overlapped by the right ischial bone. Anterior scintigraphy of the pelvis could not detect a migrated seed to the pelvis, and single photon emission computed tomography images barely showed it. Postimplant pelvic computed tomography (CT) showed that the seed had migrated to the right ischial bone.

Case 2: A postimplant chest radiograph showed a seed that had migrated to the left side of the chest. Scintigraphy of the chest successfully detected the migrated seed on the left side of the chest.

Case 3: A postimplant abdominal radiograph showed a seed that had migrated to the upper right side of the abdomen. Scintigraphy of the abdomen successfully detected the migrated seed on the upper right side of the abdomen. Postimplant abdominal CT demonstrated that the seed had migrated to the liver. None of the three patients had any symptoms related to the migrated seeds.

Conclusions: The scintigraphic technique is useful but limited in that it is difficult to detect seeds that have migrated to bone tissue.

INTRODUCTION
Seed migration after transperineal interstitial permanent prostate brachytherapy is sometimes observed, particularly when the implant is performed with loose seeds, and the most frequent site of seed migration is the lung [1-6]. An 125I seed measures 4.5 mm in length and 0.8 mm in diameter; its small size favors potential displacement mostly from the periprostatic insertion site to the adjacent prominent periglandular venous plexuses. Pulmonary seed migration is thought to occur by a mechanism in which seeds implanted or eroded into the periprostatic venous plexus migrate hematogeneously to the iliac veins, inferior vena cava, right heart, and finally the lungs [7]. Seed migration has the potential to result in a reduction in radiation dose to the prostate and, moreover, unwanted seed-related sequelae, such as an acute myocardial infarction [8]. A current standard technique for detecting migrated seeds is a postoperative conventional radiograph, in which a migrated seed is visualized as a radiopaque foreign body. However, a radiographic examination does not always detect the embolized seeds, especially when they have migrated to the lung base or to areas overlapped by bones. Furthermore, seeds in motion in the intracardiac region may not be visible on radiographs [1].

Recently, a scintigraphic technique for detecting migrated seeds after transperineal interstitial permanent prostate brachytherapy with 125I was proposed [9, 10]. One supposed merit of the scintigraphic technique is its excellent sensitivity for detection of seed migration. Previous investigators have reported 100% sensitivity with scintigraphy, while conventional radiography showed a sensitivity of 35% [9]. Moreover, scintigraphic detection is a cost-effective method that can monitor seed location with no additional irradiation.

However, few published data exist on the scintigraphic
technique in the detection of migrated seeds, and it has not been fully validated in larger studies. One drawback of this technique is that it must be performed within a limited period of time after seed implantation; when the radioactivity of a migrated seed has decreased substantially, the scintigraphic technique has some difficulty detecting it. Other possible limitations come from the low photon energy of $^{125}$I; when a migrated seed is surrounded by dense tissue, such as bone, the scintigraphic technique has some difficulty detecting it because the bony tissue may attenuate mostly low-energy photons emitted by $^{125}$I. The purpose of this retrospective study was to demonstrate and discuss the benefits and limitations of the scintigraphic technique for detecting migrated seeds after transperineal interstitial permanent prostate brachytherapy with $^{125}$I seeds.

MATERIALS AND METHODS

Ten consecutive patients underwent transperineal interstitial permanent prostate brachytherapy with $^{125}$I seeds (OncoSeed, model 6711; Amersham) with a Mick applicator (Mick Radio-Nuclear Instruments, Bronx, NY) at our institution in 2007, between February and the beginning of March. Four (40%) of the 10 patients exhibited seed migration on postimplant conventional radiographs (orthogonal chest radiographs, an abdominal radiograph, and a pelvic radiograph) at day 1 or day 18 and were informed of the seed migration. Three (75%) of the four patients who consented to participate in the study were examined by scintigraphy. The mean age of the three patients was 64 years (range, 61-66 years). All three patients had T1cN0M0 (AJCC TNM classification, 2002) adenocarcinoma of the prostate with a Gleason score of 6 (3+3). The mean prostate-specific antigen level was 5.61 ng/mL (range, 4.79 to 6.75 ng/mL). The mean preimplant prostate volume measured by transrectal ultrasonography was 26.4 cc (range, 24.6 to 28.4 cc). The prescribed dose was 145 Gy. The $^{125}$I source strength was 12.07 MBq per source on the day of the operation. A total of 249 seeds were implanted in all three patients. The mean number of seeds implanted per patient was 83 (range, 79 to 90). Postimplant conventional radiographs showed that each of these patients had one migrated seed, for a total of three seeds (1.20%) that had migrated in all three patients.

One experienced a seed migration to the pelvis (Case 1), the second to the chest (Case 2), and the third to the abdomen (Case 3). The scintigraphic examination was performed in a nuclear medicine room. Patients were scanned in the supine position using a $\gamma$-camera (e.cam; Siemens) with a medium-energy, high-resolution collimator tuned to an energy level of 35 keV with a 60% window width to cover all 3 photopeaks (27.4, 31.4, and 35.5 keV) emitted by the $^{125}$I seeds. Anterior planar images were obtained from all three patients at day 1, day 20, and day 36 (Case 1, Case 2, and Case 3, respectively).

The scanning ranges were the pelvis, from the chest to the pelvis, and from the abdomen to the pelvis (Case 1, Case 2, and Case 3, respectively). Additional single photon emission computed tomography (SPECT) data were obtained in one patient (Case 1) at day 1. Two patients who experienced seed migration to the abdomen and pelvis underwent abdominal and pelvic computed tomography (CT) to determine the actual location of the migrated seed at day 36 and day 97 (Case 3 and Case 1, respectively).

RESULTS

Case 1: A pelvic radiograph at day 1 showed a seed that had migrated to the pelvic area and that was overlapped by the right ischial bone (Figure 1A). Subsequent anterior scintigraphy at day 1 could not detect the migrated seed (Figure 1B). Additional axial and coronal SPECT images at day 1 barely showed the migrated seed (Figure 1C and 1D).

Postimplant pelvic CT at day 97 showed that the seed had migrated to the right ischial bone (Figure 1E). Six months after seed implantation, a follow-up pelvic radiograph showed that the migrated seed remained in the same position. Case 2: Orthogonal chest radiographs at day 18 showed a seed that had migrated to the left side of the chest (Figure 2A). Anterior scintigraphy at day 20 was able to detect the migrated seed successfully on the left side of the chest (Figure 2B). Case 3: An abdominal radiograph at day 18 showed a seed that had migrated to the upper right side of the abdomen (Figure 3A). Anterior scintigraphy at day 36 was able to detect the migrated seed successfully on the upper right side of the abdomen (Figure 3B). Postimplant abdominal CT at day 36 demonstrated that the seed had migrated to the liver (Figure 3C). None of the three patients had any symptoms related to the migrated seeds.

Case 1: Pelvic radiograph at day 1 after seed implantation shows a seed that has migrated to the pelvic area and that is overlapped by the right ischial bone (solid arrow) (A). Subsequent anterior scintigraphy of the pelvis at day 1 cannot detect the migrated seed, but can only detect the prostate (solid arrow) (B). Axial (C) and coronal (D) single photon emission computed tomography images of the pelvis at day 1 barely show the migrated seed (dotted arrows). Solid arrows show the prostate (C, D). Pelvic computed tomography at day 97 shows a seed that has migrated to the pelvis.
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right ischial bone (white solid arrow) (E).

Figure 1A and Figure 1E are reproduced from Figure 3 and Figure 4, respectively, of the below article with permission.

A. Sugawara, N. Shigematsu, M. Oya, J. Nakashima & E. Kunieda: Prostate Brachytherapy Seed Migration To The Ischial Bone: 2 Case Reports. The Internet Journal of Urology. 2010 Volume 7 Number 2

Figure 1
Figure 1a

Figure 2
Figure 1b
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Case 2: Anteroposterior chest radiograph at day 18 after seed implantation shows a seed that has migrated to the left side of the chest (solid arrow) (A). Anterior scintigraphy of the chest, abdomen, and pelvis at day 20 can detect both the prostate (solid arrow) and the migrated seed on the left side of the chest (dotted arrow) (B).
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Figure 7
Figure 2b

Case 3: An abdominal radiograph at day 18 after seed implantation shows a seed that has migrated to the upper right side of the abdomen (white solid arrow) (A). Anterior scintigraphy of the abdomen and pelvis at day 36 can detect both the prostate (solid arrow) and the seed that migrated to the upper right side of the abdomen (dotted arrow) (B). Abdominal computed tomography at day 36 shows a seed that has migrated to the liver (white solid arrow) (C).
DISCUSSION

The present study shows that planar scintigraphy does not always detect migrated seeds. In Case 1, anterior scintigraphy of the pelvis could not detect a seed that had migrated to the right ischial bone, and axial and coronal SPECT images of the pelvis barely showed the seed, although in Case 2 and Case 3, anterior scintigraphy was able to detect seeds that had migrated to soft tissues successfully (the lung and the liver, respectively). The reason why, in Case 1, anterior scintigraphy could not detect the migrated seed is not clear. One possible explanation is that, in Case 1, $^{125}$I photons emitted from the migrated seed might have been largely attenuated by bone tissue. As a result, anterior scintigraphy could not detect the migrated seed, and axial and coronal SPECT images of the pelvis barely showed it. In contrast, in Case 2 and Case 3, $^{125}$I photons emitted from the migrated seeds may have been less attenuated by soft tissues (the lung and the liver, respectively) compared to bone tissue. Therefore, anterior scintigraphy was able to detect the migrated seeds successfully.

It has been reported that bone tissue attenuates $^{125}$I photons much more strongly than does soft tissue because of the dominance of the photoelectric effect [11]. Previous investigators have confirmed a high attenuation coefficient in bone relative to soft tissues [12]. These theoretical explanations support our findings. However, further studies will be needed to confirm our theory.

The present study demonstrates that the scintigraphic technique would have some difficulty in detecting a seed that had migrated to hard tissue, such as bone. In Case 1, without SPECT images, the scintigraphic technique could not detect the seed that had migrated to the right ischial bone. This means that routine whole-body planar scintigraphic scans alone would be insufficient to detect a migrated seed with a scintigraphic technique of higher sensitivity. It is thought that routine whole-body SPECT scans would also be needed. Moreover, it is highly doubtful that, without radiographic information, we could correctly detect a seed that had migrated to the right ischial bone with the scintigraphic technique alone or including SPECT, because axial and coronal SPECT images barely showed it. It is thought that radiographic information is still necessary to detect a migrated seed with a higher sensitivity.

CONCLUSION

The scintigraphic technique may be a useful method for detecting seed migration after transperineal interstitial permanent prostate brachytherapy with $^{125}$I seeds. However, it has a limitation in that it has some difficulty in detecting a seed that has migrated to bone tissue.

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