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CLINICAL INVESTIGATION **Prostate**

THE USE OF LINKED SEEDS ELIMINATES LUNG EMBOLIZATION FOLLOWING PERMANENT SEED IMPLANTATION FOR PROSTATE CANCER

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Purpose: A number of reports of ^{125}I seed migration to the lungs after prostate brachytherapy have been published. There are, however, very limited data available on how to reduce the risk of this event. The purpose of the present report is to determine whether seed embolization to the lungs can be minimized by using stranded seeds alone for brachytherapy.

Methods and Materials: Between December 2001 and December 2002, 238 patients with early prostate cancer were treated with prostate brachytherapy as monotherapy using ^{125}I stranded seeds (RAPIDStrand) exclusively. All patients had fluoroscopy during the implant and immediate postimplant radiographs of the pelvis. A sample of 100 patients had chest radiographs performed, on average, 55 days after implant. To determine the ease, or lack of ease, with which these ^{125}I seeds could be visualized, 4 patients who did not have prostate cancer and who were having routine chest radiographs as part of their management for other cancers consented to have posteroanterior and lateral radiographs performed with inactive ^{125}I seeds taped to the skin of the thorax. All radiographs were reviewed by a single radiologist.

Results: The number of seeds noted on the postimplant radiographs corresponded to the number of implanted seeds in all 238 cases: There was, therefore, no evidence of seed embolization immediately postimplant. On review of the 100 chest radiographs, no embolized seeds were found.

Conclusion: No evidence of seed embolization was observed with the use of stranded ^{125}I seeds as used for prostate brachytherapy. © 2004 Elsevier Inc.

Prostate, Brachytherapy, Iodine-125, Migration, Pulmonary embolism.

INTRODUCTION

Prostate brachytherapy is an increasingly popular method of treatment for early-stage prostate cancer. Current seed implantation technique is generally based on peripheral loading (1–3) to reduce the dose to the urethra. This technique often requires seeds to be implanted adjacent to the prostatic margin, which may be associated with seed embolization to the lungs (3–16).

Steinfeld *et al.* (11) were the first to report pulmonary seed embolization after prostate brachytherapy. The likely explanation is that an ^{125}I seed (4.5 mm in length and 0.8 mm in diameter) is small enough to migrate through the dense venous plexus surrounding the prostate. Seeds entering the venous system access the right heart and then embolize and become lodged in the lungs (3). Seed migration to other sites has been reported (17, 18) and is most likely explained by the presence of a right-to-left intracardiac shunt.

There have been a number of literature reports addressing the risk of seed embolization (19–21). The aim of this study was to investigate the incidence of ^{125}I seed embolization with stranded seeds only (RAPIDStrand).

METHODS AND MATERIALS

Transperineal prostate brachytherapy at Cookridge Hospital began in 1995 and, to date, over 1100 implants have been performed. Implant techniques have evolved over the years, but in essence are still based on the preplan method. Between 1995 and September 1999, all patients were implanted with ^{125}I free seeds. After this, RAPIDStrand was introduced. Initially, these stranded seeds were restricted to needles placed at the periphery of the prostate with no extracapsular placement. The periurethral areas were implanted with free seeds. Since December 2001, RAPIDStrand has been used exclusively for all our prostate implants.

Between December 2001 and December 2002, 238 pa-

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tients were implanted. The average treated prostate volume was 31.9 cc (range, 11.7–54.0 cc). The average number of seeds implanted was 81 (range, 44–115 seeds) with average activity of 0.460 U (range, 0.413–0.492 U) loaded into an average of 30 needles (range, 20–40 needles) to deliver a prescribed dose of 145 Gy (1, 2).

All patients had fluoroscopy during the implant as per normal procedure for this institution. One hundred consecutive patients had chest radiographs (posteroanterior [PA]), performed on average 55 days after implant (median, 53 days; range, 24–115 days). These radiographs were reviewed by a single radiologist (B.C.), who is familiar with prostate brachytherapy.

Four patients who did not have prostate cancer consented to have chest radiographs to act as a reference group. None of these 4 patients had any known chest pathology but did require chest radiography as part of their management. The purpose of this was to explore the ease of visualization of ^{125}I seeds on PA and lateral chest radiographs. Inactive ^{125}I seeds were taped to various parts of the chest wall, and the ease of identification was noted over different tissues (lung parenchyma, heart, spine, and ribs).

RESULTS

(*A*) The seed count on immediate postimplant pelvic radiographs equated to the number of implanted seeds in all 238 patients. There was, therefore, no evidence of seed loss immediately after the implant. (*B*) No evidence of seed embolization to the lungs was observed on the sample of 100 consecutive chest radiographs. (*C*) Seeds were clearly visible on all 4 control patients—both PA and lateral projections.

DISCUSSION

In common with other groups, we did occasionally observe seed embolization to the lungs with the use of free ^{125}I seeds. The clinical consequences relating to these embolized seeds were considered negligible—the main concern was the reduction in the number of seeds contributing to dose in the prostate gland itself. The introduction of stranded seeds (22) was considered an advantage by our group and was therefore incorporated into our brachytherapy technique. Stranded seeds have been reported to improve the implant dosimetry (23), as well as reduce the possibility of seed embolization from 11.6% to 0.7% compared to free seeds (3). The results of our study suggest that the exclusive use of RAPIDStrand seeds may eliminate the risk of seed embolization to the lungs.

RAPIDStrand was initially used in our center in conjunction with a few free seeds that were implanted around the urethra. This technique was adopted to avoid excess preurethral dosage. Free seeds were loaded in brachytherapy needles using spacers that left sufficient gaps between free seeds, as planned. Recently, this technique has been replaced by one using only linked seeds for the whole implant. To maintain an acceptable urethral dose, a split needle method was introduced. For example, if a plan produces a single needle containing 2 seeds at 0.0-mm retraction from the base and another 2 seeds at 40.0-mm retraction, this needle is divided into 2 needles (splits). The first needle contains 2 linked seeds to be implanted at 0.0-mm retraction, and the second needle contains another 2 linked seeds to be implanted at 40.0-mm retraction using the same coordinate on the ultrasound template. This method may increase seed fixity and, hence, improve dosimetry and eliminate seed migration, as well as avoid an excessive urethral dose.

RAPIDStrand is ^{125}I seeds linked by a braided, tissue-absorbable suture material made of Polyglactin 910. Experimental i.m. implantation studies of Polyglactin 910 show absorption begins as a loss of tensile strength followed by a loss of mass. The suture material retains approximately 75% of the original tensile strength at 2 weeks postimplantation. All of the original tensile strength is lost between 4 and 5 weeks postimplantation. Absorption is essentially complete between 56 and 70 days (RAPIDStrand instructions for use). The seeds, however, should be well epithelialized within the gland by this time, and so migration and embolization are unlikely to occur even after suture absorption. Our study supports this view with no evidence of any seed embolization observed.

Visualization of ^{125}I seeds on chest radiographs might be influenced by a number of factors. If the seed is lying behind high-attenuation regions, such as bony structures or the heart, it might be less visible on the chest radiographs. ^{125}I seeds are, however, very radiopaque (silver and titanium shell), and there was no problem identifying these seeds on the chest radiographs of the control patient group, regardless of site or radiographic projection. Furthermore, all chest radiographs were reviewed by an experienced radiologist familiar with prostate brachytherapy, who had the specific purpose of identifying seeds. We do not consider, therefore, that seeds could have been overlooked or rendered inconspicuous in our study.

CONCLUSION

The exclusive use of stranded seeds for prostate brachytherapy is associated with a negligible risk of seed embolization to the lungs. This should minimize any detrimental effect on prostate dosimetry resulting from possible seed loss, as well as eliminate any potential risk of radiation toxicity to organs affected by seed embolization.

REFERENCES

1. Nath R, Anderson LL, Luxton G, *et al.* Dosimetry of interstitial brachytherapy sources: Recommendations of the AAPM Radiation Committee Task Group No. 43. *Med Phys* 1995;22:209–234.

2. Luse RW, Blasko J, Grimm P. A method of implementing the American Association of Physicists in Medicine Task Group-43 dosimetry recommendations for 125I transperineal prostate seeds implants on commercial treatment planning systems. *Int J Radiat Oncol Biol Phys* 1997;37:737–741.
3. Tapen EM, Blasko JC, Grimm PD, *et al.* Reduction of radioactive seed embolization to the lung following prostate brachytherapy. *Int J Radiat Oncol Biol Phys* 1998;42:1063–1067.
4. Ankem MU, DeCarvalho VS, Harangozo AM, *et al.* Implications of radioactive seed migration to the lungs after prostate brachytherapy. *Urology* 2002;59:555–559.
5. Guigauri P, Watkins MW. Lung embolization of prostate cancer brachiotherapy seeds: Incidental finding during left heart catheterization (Letter). *J Invasive Cardiol* 2002;148: A22.
6. Gupta S, Nag S, Gupta J. Pulmonary embolization of permanently implanted radioactive iodine-125 seeds. *Endocuriether Hypertherm Oncol* 1993;9:27–31.
7. Merrick GS, Butler WM, Dorsey AT, *et al.* Seed fixity in the prostate/periprostatic region following brachytherapy. *Int J Radiat Oncol Biol Phys* 2000;46:215–220.
8. Hempel M, Bruggmoser G, Wannenmacher M. A rare complication in interstitial therapy with iodine-125 seeds: "Embolization of seed into the lung." *Strahlenther Onkol* 1988;164: 531–532.
9. Hunttner S, Lengsfeld M, Scholz H. A rare route for the loss of a I-125 seed after the interstitial therapy of prosthetic carcinoma. *Urologe-Ausgabe* 1992;31:96–97.
10. Sommerkamp H, Rupprecht M, Wannenmacher M. Seed loss in interstitial radiotherapy of prostatic carcinoma with I-125. *Int J Radiat Oncol Biol Phys* 1988;14:389–392.
11. Steinfeld AD, Donahue BR, Planine L. Pulmonary embolization of Iodine-125 seeds following prostate implantation. *Urology* 1991;37:149.
12. Van't Riet A, Te Loo HJ, Ypma AF, *et al.* Ultrasonically guided transperineal seed implantation of the prostate: Modification of technique and qualitative assessment of implants. *Int J Radiat Oncol Biol Phys* 1992;24:555–558.
13. Welle GJ, Quinn K. Pulmonary embolization of iodine-125 implants. *Am J Roentgenol* 1992;159:218.
14. Dafoe-Lambie JC, Abel LJ, Blatt HJ, *et al.* Radioactive seed embolization to the lung following prostate brachytherapy. *W V Med J* 2000;96:357–360.
15. Eshleman JS, Davis BJ, Wilson TM, *et al.* Radioactive seed migration to the chest following transperineal interstitial prostate brachytherapy for early stage prostate carcinoma. *Int J Radiat Oncol Biol Phys* 2001;51:297–298.
16. Grimm PD, Blasko JD, Ragde H, *et al.* Migration of iodine-125 and palladium-103 seeds to the lung after transperineal brachytherapy for prostate cancer. *Endocuriether Hypertherm Oncol* 1993;9:50.
17. Davis BJ, Bresnahan JF, Stafford SL, *et al.* Prostate brachytherapy seed migration to a coronary artery found during angiography. *J Urol* 2002;1683:1103.
18. Davis BJ, Pfeifer EA, Wilson TM, *et al.* Prostate brachytherapy seed migration to the right ventricle found at autopsy following acute cardiac dysrhythmia. *J Urol* 2000;1645:1661.
19. Nag S, Scaperoth DD, Badalament R, *et al.* Transperineal palladium 103 prostate brachytherapy: Analysis of morbidity and migration. *Urology* 1995;45:87–92.
20. Nag S, Vivekanandam S, Martfinez-Monge R. Pulmonary embolization of permanently implanted radioactive palladium-103 seeds for carcinoma of the prostate. *Int J Radiat Oncol Biol Phys* 1997;39:667–670.
21. Older RA, Synder B, Krupski TL, *et al.* Radioactive implant migration in patients treated for localized prostate cancer with interstitial brachytherapy. *J Urol* 2001;165:1590–1592.
22. Kumar PP, Good RR. Vicryl carrier for I-125 seeds: Percutaneous transperineal insertion. *Radiology* 1986;159:276.
23. Lee WR, deGuzman AF, Tomlinson ST, *et al.* Radioactive sources embedded in suture are associated with improved postimplant dosimetry in men treated with prostate brachytherapy. *Radiother Oncol* 2002;65:123–127.