Journal of Medical Sciences

ISSN 1682-4474

science alert

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Research Paper

J. Med. Sci., 8 (4): 429-432
15th June, 2008

JMS (ISSN 1682-4474) is an International, peer-reviewed scientific journal that publishes original article in experimental & clinical medicine and related disciplines such as molecular biology, biochemistry, genetics, biophysics, bio-and medical technology. JMS is issued eight times per year on paper and in electronic format.

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Comparison of Conventional Radiotherapy Techniques with Different Energies in Treating Prostate Cancer, Employing a Designed Pelvis Phantom

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The aim of this study is to determine and compare the dosimetric consequences of prostate and normal structures (rectum, bladder and right femoral heads) in pelvis region using different conventional radiotherapy techniques 4-field (box), 3-field with one anterior and two oblique 115 and 245° fields and anterior-posterior technique) with two different energies of 9 and 18 MV. In this study two high-energy linear accelerators (Neptun 10 and Saturn 20) located in Seyed-Alshohada hospital in Isfahan were used. An anthropomorphic pelvic phantom was designed and fabricated for dosimetry applications based on the pelvic CT images of an adult patient with an average size of prostate cancer patients referring to the medical center. Measurements of the organ doses was performed in phantom using TLD (TLD-100) dosimeters, which was suited at different depth especially in prostate, rectum, bladder and femur head. After drawing the fields on the phantom, the photon beam at a dose of 200 cGy with various levels of photon energy (9 and 18 MV) were used. One way ANOVA test was used to data analysis. The measured percentage depth dose (DD%) in 4-field technique using photon 9 MV to the prostate, rectum, bladder and right femoral heads were 94.8, 85.71, 77.51 and 65.81%, respectively and using 18 MV photon beam they were 95.81, 86.73, 77.5 and 63.45%, respectively. The amount of DD%, in the 3-field technique with 9 MV photon, to the prostate, rectum, bladder and right femoral heads was found to be 91.7, 78.83, 93.4 and 63.25%, respectively and 92.38, 79.05, 93.31 and 62.05% when 18 MV photon beam were used. Using the 9 MV photon beam in AP-PA technique, prostate, rectum, bladder and right femoral heads received 96.23, 96.77, 96.3 and 28.77% of prescribed doses, while with 18 MV photon radiation they were 95.77, 96.91, 95.82 and 26.69%, respectively. Differences among the techniques have been found for all of four considered organs with total prescribed dose of 60 Gy and there was no significant difference among all considered techniques. Technique 3-filed give the best sparing of the rectum; the bladder is better spared with technique box and the best technique for sparing the femoral head is AP-PA. Differences between energies were low and using 18 MV photons give the more satisfied results.

Key words: Prostate cancer, conventional radiotherapy, dosimetry, linac, TLD

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INTRODUCTION

Carcinoma of the prostate is the most frequent noncutaneous malignant disease and is the third leading cause of cancer-related death in men (Jemal *et al*., 2006). The established risk factors for the disease include race, age and family history (Bostwick *et al*., 2004). The prognosis for patients with prostate cancer is variable and depends on the tumor-related characteristics at diagnosis. For patients with non-metastatic prostate cancer, there are many treatment options, including observation, surgery, external beam radiation therapy, brachytherapy or hormonal manipulation with or without radiation therapy (Pilepich *et al*., 1997; Mettlin *et al*., 1997; Khoo *et al*., 2000; Jani and Hellman, 2003; Thomas and Pisansky, 2006). During the past four decades, External Beam Radiation Therapy (ERT) has been a mainstay in the management of prostate cancer and continues to be used in the treatment of almost one third of all patients receiving definitive therapy (Mettlin *et al*., 1997; Bedford *et al*., 1999; Milecki *et al*., 2004; Hille *et al*., 2006).

External-beam radiotherapy has several advantages over others (Kron *et al*., 2002; Jani and Hellman, 2003; Hille *et al*., 2006; Harrison *et al*., 2006; Schneider *et al*., 2007). It is non-invasive treatment and has no surgical risks. It may be offered to patients for reasons of age, general health, or specific coexisting conditions might tolerate prostatectomy poorly. In addition, urinary incontinence is less common after radiotherapy than after surgery.

The most important disadvantage is the risk of adverse effects caused by the irradiation of normal organs, particularly the rectum. In addition, treatment with radiotherapy does not include pathological confirmation of disease stage; if spread beyond the prostate has occurred, it cannot be detected directly (Thomas and Pisansky, 2006; Schneider *et al*., 2007).

The rate of success in ERT is directly related to given dose to the tumor but the late chronic side-effects limit the dose that can be given in ERT. Today, with the use of modern radiotherapy techniques such as 3-dimensional conformal radiation therapy (3D-CRT) and intensity-modulated radiation therapy (IMRT), increasing the radiation dose to the tumor while minimizing the normal tissue complication rate is possible. In Iran and many developing countries the accesses to this new technologies is difficult and the use of conventional techniques is common. Both radiation dose to the target and organs at risk is important for the outcome of radiation therapy of the prostate. The aim of this study is to compare the depth dose of 9 and 18 MV photon beams in the rectum, bladder, right femoral head and prostate when the pelvis was irradiated in techniques most frequently used for conventional radiotherapy of the prostate cancer 4-field (box), 3-field (with one anterior and two oblique 115 and 245° fields) and anterior-posterior technique.

MATERIALS AND METHODS

This study was conducted in Seyed Al-Shohada hospital of Isfahan, Iran in 2007. Photon sources used in this study were a Saturn 20 (CGR Ltd., France) and Neptun 10 (Zdaj, Poland) Linear accelerators located in Seyed Al-Shohada hospital of Isfahan, Iran. An anthropomorphic pelvic phantom was designed and fabricated for dosimetry applications based on the pelvic CT images of an adult patient with an average size of prostate cancer patients referring to the medical center. The phantom of pelvic was constructed using Perspex blocks (Perspex is usually easily accessible, hard enough to perform the task, can be cut in different necessary thicknesses and also it is nearly equivalent to the soft tissue). The material used for bone phantom was Teflon, which has the properties of bone materials (Muren *et al*., 2003).

To obtain the necessary sizes for phantom construction, preliminary measurements of 10 patients referred to the Radiotherapy Department of Seyed Al-Shohada hospital were performed. Contour sizes of the patients were obtained for a mean patient size with 95% confidence limits. A photograph of phantom was shown in Fig. 1.

To measure the mean organ dose and the percentage depth dose (DD%), Thermoluminescent Dosimeter (TLD) was used. The lithium fluoride chips (LiF:Mg, Tl) is the most commonly used thermoluminescent material for patient dosimetry. Thermoluminescent dosimeters were first prepared and calibrated in accordance with manufacturer's recommendation and the data was appended manually to the spreadsheet to provide an

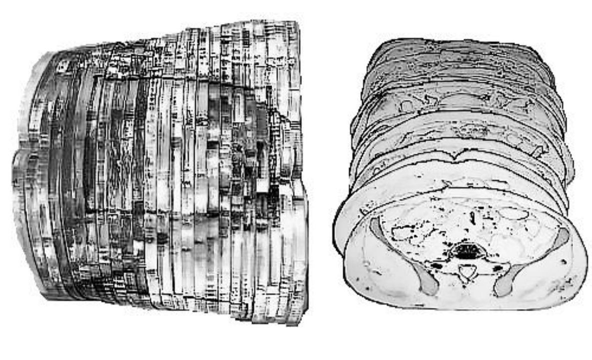

Fig. 1: Schematics of designed phantom in this study

alternate assessment of the quantity absorbed dose (including backscatter). In the phantom suitable holes were made at critical locations of the pelvis such as prostate, rectum, bladder and right femoral heads.

The treatment field for each technique includes four-field conformal technique (box treatments), 3-field (with one anterior and two oblique 115 and 245° fields) and anterior-posterior technique (AP-PA) was drawn on the pelvis phantom by radiotherapist. The irradiation technique was SAD (source to axis distance) and the applied dose was 200 cGy. After positioning the TLDs at the predetermined locations of the phantom and positioning the phantom on the treatment coach of the linacs and adjusting the radiation field, a dose of 200 cGy was applied to the phantom. The above procedure was repeated 6 times for both 9 and 18 MV photon beams of the two linacs. After each irradiation of the phantom, TLDs were removed and the recorded doses were read using the Solaro 2A TLD reader located in the Department of Medical Physics of Isfahan University of Medical Sciences. To measure the dose at different locations, several measurements was done and an average of the values multiplied to correction factors (individual and group correction factors) of TLDs was calculated as the mean dose of each organ.

RESULTS AND DISCUSSION

As can be shown from Table 1, for prostate, box technique with photon energy of 18 MV is better than the other techniques, while 3-field technique is the worst. For sparing the rectum, 3-field technique with photon energy of 9 MV has priority to the others, whereas AP-PA technique is the worst. The exposure of the bladder was significantly lower for the box technique when compared with both 3-field and AP-PA techniques. The recommended technique for the femoral head sparing was the AP-PA and there was no significance differences between 3-field and box techniques.

The measured DD% in 4-field technique to the prostate, rectum, bladder and right femoral heads were 94.8, 85.71, 77.51 and 65.81%, respectively when, the photon energy was 9 MV and they were 95.81, 86.73, 77.5 and 63.45% when 18 MV photon beams were used (Fig. 2).

The percentage depth dose (DD%), in the 3-field technique with 9 MV photon, to the prostate, rectum, bladder and right femoral heads respectively are 91.7, 78.83, 93.4 and 63.25% and they were 92.38, 79.05, 93.31 and 62.05% when 18 MV photon beam were used. Using the 9 MV photon beams in AP-PA technique, prostate, rectum, bladder and right femoral heads received 96.23, 96.77, 96.3 and 28.77% of prescribed doses, while with 18 MV photon radiation they were 95.77, 96.91, 95.82 and 26.69%.

For prostate, box technique with photon energy of 18 MV showed better results than the other techniques, while 3-field technique was the worst. For sparing the rectum, 3-field technique with photon energy of 9 MV has priority to the others, whereas AP-PA technique is the worst. The exposure of the bladder was significantly lower for the box technique when compared with both 3-field and AP-PA techniques (Table 1). The recommended technique for the femoral head sparing was the AP-PA and there was no significance differences between 3-field and box techniques.

Significant technical advances in recent years have permitted the development of safe, high dose radiotherapy techniques for localized prostate cancer,

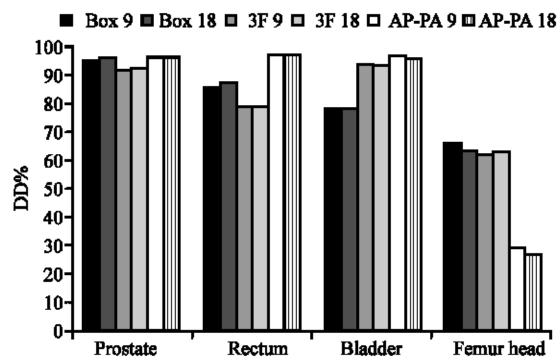

Fig. 2: The percentage depth dose (DD%) of different organs (total prescribed dose to the prostate of 60 Gy) in accordance with 3-field (3F), box and AP-PA techniques considering 9 and 18 MV energy levels

Table 1: The mean dose of studied organs for total prescript dose of 60 Gy

		[Organ mean dose (Gy)±SD]*			
Technique	Photon energy (MV)	Prostate	Rectum	Bladder	Right femur head
3-field	9	55.02±0.40	47.30±0.30	56.04±0.55	37.23±0.89
	18	55.43±0.28	47.43±0.51	55.99±0.29	37.83±0.42
4-field (box)	9	56.88±0.54	51.43±0.84	46.51±0.46	39.49±0.31
	18	57.49±0.74	52.04±0.58	46.50±0.270	38.07±0.69
AP-PA	9	57.74±0.36	58.06±0.21	57.78±0.42	17.26±0.73
	18	57.46±0.48	58.14±0.46	57.49±0.31	16.01±0.76

*Data obtained from six measurements in different locations with improved treatment efficacy. Future developments, including improved imaging techniques for target volume definition, treatment planning algorithms to optimize radiation dose distributions and methods for verifying precise geometric and dosimetric accuracy of treatment delivery, hold out the prospect of further advances in treatment efficacy while reducing treatment-related side-effects. In conventional radiotherapy field, the studies investigation various techniques draw differing conclusion concerning the best irradiation technique. Some studies, comparing four and three-field techniques concluded the three-field technique to be best in rectal dose sparing (Khoo *et al*., 2000; Milecki *et al*., 2004). Others did not confirm these results (Bedford *et al*., 1999; Greco *et al*., 2003). The reason for these differing findings is unclear, but seems the different Clinical Target Volumes (CTV) in theses studies could have been responsible for different findings.

In this study, differences among the techniques and energy's have been found for all four considered organs with total prescript dose (60 Gy). Overall, there is no technique that is absolutely better than the others. Technique 3-filed give the best sparing of the rectum; the bladder is better spared with technique box and the best technique for sparing the femoral head is AP-PA. Differences between energies were low and using 18 MV photons give the more satisfied results.

REFERENCES

Bedford, J.L., V.S. Khoo, M. Oldham, D.P. Deanaley and S. Webb, 1999. A comparison of coplanar four-field techniques for conformal radiotherapy of the prostate. Radiother. Oncol., 51: 225-235.

Bostwick, D.G., H.B. Burke, D. Djakiew, S. Euling and S.M. Ho *et al*., 2004. Human prostate cancer risk factors. Cancer, 101: 2371-2490.

Greco, C., C. Mazzetta, F. Cattani, G. Tosi, S. Castiglioni, A. Fodor and R. Orecchia, 2003. Finding dose-volume constraints to reduce late rectal toxicity following 3D-conformal radiotherapy (3D-CRT) of prostate cancer. Radiother. Oncol., 69: 215-222.

Harrison, R.M., M. Wilkinson, A. Shemilt, D.J. Rawlings, M. Moore and A.R. Lecomber, 2006. Organ doses from prostate radiotherapy and associated concomitant exposures. Br. J. Radiol., 79: 487-496.

Hille, A., N. Tows and C.F. Hess, 2006. A comparison of three-filed and four-filed techniques in different clinical target volumes in prostate cancer irradiation using dose volume histogram: A prospective three-dimensional analysis. Br. J. Radiol., 79: 148-157.

Jani, A.B. and S. Hellman, 2003. Early prostate cancer: Clinical decision-making. Lancet, 361: 1045-1053.

Jemal, A., R. Siegel, E. Ward, T. Murray, J. Xu, C. Smigal and M.J. Thun, 2006. Cancer statistics, 2006. CA Cancer J. Clin., 56: 106-130.

Khoo, V.S., J.L. Bedfford, S. Webb and D.P. Deanaley, 2000. An evaluation of three-field coplanar plans for conformal radiotherapy of prostate cancer. Radiother. Oncol., 55: 31-40.

Kron, T., C. Hamilton, M. Roff and J. Denham, 2002. Dosimetric intercomparison using an anthropomorphic phantom. Int. J. Rad. Onc. Biol. Phys., 52: 566-579.

Mettlin, C.J., H.R. Menck, D.P. Winchester and G.P. Murphy, 1997. A comparison of breast, colorectal, lung and prostate cancers reported to the national cancer data base and the surveillance, epidemiology and end results program. Cancer, 79: 2052-2061.

Milecki, P., T. Pitrowski and M. Dymnicka, 2004. The comparison of radiotherapy techniques for treatment of the prostate cancer: The three-field vs. the four field. Neoplasma, 51: 64-69.

Muren, L.P., R. Smaaland and O. Dahl, 2003. Organ motion, set-up variation and treatment margins in radical radiotherapy of urinary bladder cancer. Radiother. Oncol., 69: 291-304.

Pilepich, M.V., R. Caplan, R.W. Byhardt, C.A. Lawton and M.J. Gallagher *et al*., 1997. Phase III trial of androgen suppression using Goserelin in unfavorable-prognosis carcinoma of the prostate treated with definitive radiotherapy: Report of RTOG Protocol 85-31. J. Clin. Oncol., 15: 1013-1021.

Schneider, U., A. Lomax, J. Besserer, P. Pemler, N. Lombriser and B. Kaser-Hotz, 2007. The impact of dose escalation on secondary cancer risk after radiotherapy of prostate cancer. Int. J. Radiat. Oncol. Biol. Phys., 68: 892-897.

Thomas, M.P., 2006. External-beam radiotherapy for localized prostate Cancer. N. Engl J. Med., 355: 1583-1591.