ASSESSMENT OF SET-UP ERROR IN THREE-DIMENSIONAL CONFORMAL RADIOTHERAPY (3-DCRT) DURING THE TREATMENT OF PATIENTS WITH PROSTATE OR BLADDER CANCERS IN AYADI EL-MOSTAKBAL HOSPITAL (ALEXANDRIA, EGYPT)

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ABSTRACT:

Background*: 3DCRT is the most common form of radiotherapy for prostate and bladder cancers, and reducing the uncertainty is becoming critical.*

Aim: *The study aimed to assess the set-up error in the 3-DCRT.*

Methods: *Ten prostate and ten bladder cancer patients were included. Digitally reconstructed radiographs (DRRs) were used to import electronic portal imaging devices (EPID) from radiotherapy planning (RTP) and used for comparison with portal images (PIs) as reference images, which were reconstructed from CT images. The mean displacements between DRRs and EPID were compared (for all images in the three axes). The planning target volume (PTV) margin was calculated using, Stroom, van Herk's formulae, and ICRU report 62.*

Results: *Set-up error was within 9.82 for prostate and 8.36 mm for bladder cancers. The overall mean values of displacements were 7.96, 4.16, and 3.97 mm for the prostate and 6.59, 3.66, and 3.63 mm for the bladder along lateral, vertical, and longitudinal axes, respectively. For the prostate, the systematic error was 4.91, 3.32, and 3.23 mm in Medio-lateral (ML), Anterior-to-Posterior (AP), and superior-inferior (SI) directions. The random error was ML; 6.2, AP; 2.3, and SI; 2.5 mm. For bladder, the systematic error was ML; 4.1, AP; 2.55, and SI; 2.65 mm, while the random error was ML; 4.1, AP; 2.55, and SI; 2.65 mm. The best PTV margin is achieved by using van Herk's formula in all directions for cancers.*

Conclusions: *Set-up alignment protocols should be followed drastically for prostate and bladder cancers in Egyptian RT new centers.*

Keywords: Bladder cancer; Prostate cancer; set-up error; 3-DCRT.

INTRODUCTION:

The incidence and mortality cases of both bladder and prostate cancers are expected to be doubled from 2018 to 2070 globally[1]. Bladder cancer (BC) new cases and mortality in Egypt are expected to increase from 2020 to 2040 (New cases: from 8.41 to 15.4 thousand among males and from 2.25 to 4.21 thousand among females; Mortality: from 4.85 to 9.5 thousand among males and from 1.32 to 2.61 thousand among females) [https://gco.iarc. fr/tomorrow/en/dataviz]. BC is four times higher in men [2]. In addition, prostate cancer incidence and mortality in Egypt are expected to increase

from 2020 to 2040 as well (New cases: from 4.47 to 9.61 thousand among males; Mortality: from 2.23 to 4.98 thousand among males) [https://gco.iarc.fr/ tomorrow/ en/dataviz].

Radiotherapy (RT) has a high cure rate (≥ 80%) for many cancers, depending on how early the treatment has begun. Conformal radiotherapy (CRT) generates a high dose volume closely conformed to the desired clinical target volume (CTV) while reducing the dose to the surrounding organs at risk (OAR)[3&4]. Three-dimensional 3D-CRT involves complex processes of accurate patient set-up, complete immobilization in the treatment position, complex beam modeling; based on a 3D reconstruction of the proper single or fused imaging modalities; and a computer-aided calculation of dose distribution[5].

Proper patient immobilization and set-up ensure optimum precision and reproducibility in dose delivery and distribution[6]. Set-up errors, including random and systematic errors, can be estimated, verified, and eliminated using consecutive portal images (PIs) collected during the treatment[7-10]. The set-up errors in the radiation therapy treatment can negatively affect the accuracy of the treatment. Therefore, it is essential to add a safety margin around the tumor to assure that the radiation dose will cover the whole tumor size[11].

The current study was designed to assess systematic and random errors in 3D-CRT while treating patients with prostate or bladder cancers in Ayadi El-Mostakbal hospital, one of the newly established Egyptian radiotherapy hospitals using an EPID.

PATIENTS AND METHODS:

The study population consisted of two groups of patients (with 200 portal images and 300-point positions available for analysis); prostate (ten patients; 50% aged >70 years; 60% > 34 BMI) and bladder cancers (ten patients; 50% aged >70 years; 60% > 30 BMI) randomly selected from those referred to Ayadi El-Mostakbal hospital, Alexandria, Egypt from 2016 to 2017. Selected patients were enrolled after obtaining informed consent (according to the ethical principles stated in the Belmont report (https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/read-the-belmont-report/index.html) and treated by 3D-CRT.

Patients are positioned using laser alignment and knee immobilized. The patient coordinate system is defined according to the International Electrotechnical Commission (IEC 2000). A planning CT scan was performed using a SOMATOM CT scanner (Siemens) according to the 3-DCRT guidelines for prostate and bladder cancers [12, 13]. Patients were scanned in the treatment supine position [for the prostate: with comfortably filled bladder, empty rectum, and low residue diet; for bladder: empty bladder, empty rectum, and bladder intervention with fused MRI/CT (if needed) protocols] using a knee-ankle fixation device to facilitate set-up reproducibility. Patients were scanned from the level of the lower chest to the level of the end of the pelvis, with a scan thickness and index of 3-5 mm (5 mm for the prostate and 3-5 mm for the bladder).

Patients were planned with anterior and two-lateral positions. The isocenter of all three fields was set at their matching midline. All calculations were done for a dose of 200 cGy/fraction. The treatment planning (TP) was evaluated quantitatively from DVHs and qualitatively from (axial cuts). After accepting the TP, it was transferred to LANTIS ® (version 6.1, Siemens Medical Solutions, USA) to be reviewed and moved to the LINAC for treatment.

Images were sent to the oncologist to delineate the target volumes and the OAR. Subsequently, the images were sent to the TP computed medical system (CMS) (XiO 4.64, 2007). PIs were acquired using BEAMVIEW® (Siemens Medical Solutions, USA). The maximum available field size is 40 x 40 cm^2. Three-dimensional dose verification and positioning were done using EPID images. EPID images were acquired at a dose rate of 200 MUs per minute, and 4–8 MUs were delivered per field for portal acquisition. A double-exposure portal image of the anterior and lateral fields was obtained. Five PIs per field were acquired through fractionated RT for each patient. The small dose delivered by portal imaging was not considered when calculating the final total dose received by any patient. Reference images from CMS (XiO) treatment planning software (4.64) were compared to the PIs. Image acquisition, matching procedures, and the CT-acquired image series are used for creating the reference images needed for image matching.

These reference images are created using the "external beam planning" center and are Digitally Reconstructed Radiographs (DRR). They were designed for the orthogonal portals [anterior set-up with Gantry (0) angle and lateral set-up with Gantry (90 OR 270)] with fixed field sizes of (22 x18) cm^2 taken at the isocenter. The DRRs were imported from the TP to the treatment machine and were compared on the screen with the electronic portal imaging (EPI) protocols. Displacements between DRRs and EPID were analyzed and set-up errors were evaluated.

In a single-phase treatment plan, patients with prostate cancer were treated to a total dose of 74 Gy in 37 fractions of 2 Gy/fraction over 7.5 weeks. Two-phases**,** Phase 1: prostate _ SV 56 Gy in 28 daily fractions given in 5 (1⁄2) weeks. Phase 2: prostate 18 Gy in 9 daily fractions given in 11–13 days. Patients with bladder cancer were treated to a total dose of 64 Gy in 32 fractions of 2 Gy over 6.5 weeks (five fractions per week; 200cGy/fraction) or 55 Gy in 20 fractions over four weeks. In two-phase treatment plans, patients were treated with three fields with high-energy photons (6-15 MV x-rays) on Medical Linear Accelerator (Siemens Artist LINAC). The findings on clinical examination and CT and/or MRI before RT were used to constitute the gross tumor target volume (GTV), the clinical target volume (CTV), and the planning target volume (PTV). The PTV volumes were planned for possible set-up errors by adding no less than 0.5 cm to the CTV. The beams are confirmed with the help of 160-leaf MLC to the PTV. Results were analyzed by IBM SPSS software package version 20. Errors were calculated using EXCEL Microsoft Office 2016 software. Histograms were created using a vision test.

RESULTS:

The patient's demographic and clinical data are shown in Supplementary table 1. Comparison between the DRR and EPID images showed that the plan based on EPID was accomplished, and the planned dose to both target and the OAR received 100% of the prescribed radiation dose. As the iso-dose lines of the bilateral fields matched that of the AP field, a homogeneous dose coverage over the whole treatment target was achieved. The resulting matching differences in the AP, ML, and SI directions were 0.7, 0.32, and 0.4 cm, respectively. Thus, the patient shifted 0.70, 0.32, and 0.40 cm displacements toward the anterior, right, and superior directions from his original position.

Supplemetary Table 1. Demographics and clinical data of patients.		
Parameters	Prostate cancer (n, %)	Bladder cancer (n, %)
Age (Years)		
Range	55-75	59-79
Median	70.5	70
BMI		
Range	28.7-37.7	26-34.3
Median	34.4	31.1
Tumor type		
Carcinoma	7 (70)	0 (0)
Lymphoma	3 (30)	0 (0)
Urothelial carcinoma	0 (0)	10 (100)
Tumor stage		
I	0 (0)	7 (70)
II	0 (0)	3 (30)
III	7 (70)	0 (0)
IV	3 (30)	0 (0)
Tumor size (mm?)		
Range	69.3-94.5	124.3-162
Median	83.95	152
Lesion size (mm)		
60-70	1 (10)	0 (0)
70-80	4 (40)	0 (0)
80-90	1 (10)	0 (0)
90-100	4 (40)	0 (0)
120-130	0 (0)	1 (10)
130-140	0 (0)	1 (10)
140-150	0 (0)	3 (30)
150-160	0 (0)	3 (30)
160-170	0 (0)	2 (20)
Treatment		
RT plus CT	7 (70%)	10 (100%)
RT plus CT plus S	2 (20%)	0 (0%)
RT plus CT plus S plus HT	1 (10%)	0 (0%)

RT: Radiotherapy; CT: Chemotherapy; S: surgery; HT: Hormone therapy.

Results documented displacements in the set-up errors for the medico-lateral direction (ML), the anterior-to-posterior (AP), and the superior-inferior (SI) directions in both prostate and bladder cancer 3D-CRT (Figures 1-3). The set-up accuracy was 3.1 mm. The detected systemic set-up error of the prostate was: in ML; 4.91 mm, AP; 3.32 mm, and SI; 3.21 mm. The value of random error was found to be; 6.2 mm in ML, 2.57 mm in AP, and 2.4 mm in SI directions. The systemic set-up error of the bladder was in ML; 4.1 mm, AP; 2.65 mm, and SI; 2.85 mm. In addition, the random error value is ML; 5.15 mm, AP; 2.5 mm, and SI; 2.2 mm.

The mean displacement values for prostate cancer were 7.96, 4.16, and 3.97 mm long lateral, vertical, and longitudinal axes. While the overall mean values of displacement were 6.59, 3.66, and 3.63 mm long lateral, vertical, and longitudinal axes for bladder cancer. The mean displacements were compared for all images in the significant three axes as depicted in figure 4.

In our study, the PTV margin was calculated using the ICRU 62 Eq. [14], Stroom Eq. [15], and Van Herk Eq. [16]. For prostate cancer, the values were 7.96 mm, 14.2 mm, and 16.7 mm in ML, 4.17 mm, 8.4 mm, and 10.1 mm in AP, and 4.6 mm, 9.6 mm, and 11.6 mm in SI; respectively. For bladder cancer, the values were AP; 3.65

mm, 7.1 mm, and 8.39 mm; ML: 6.88 mm, 12.1 mm, and 14.12; SI: 3.65 mm, 7.69 mm, and 9 mm; respectively. Changes in the dose received in the PTV and OAR, which occurred due to the variation of lateral (x), vertical (y), and longitudinal (z) directions, were shown in Figures 5-7 for the prostate and 8-10 for the bladder; respectively. The lowest PTV margin is achievable by using the ICRU62 equation in all directions. The PTV coverage depends on the displacement between the origin set-up and maximum displacement in the three directions (negative and positive x. y. z).

ICRU62 ML calculated the PTV margins; 6.9 mm, AP; 3.7 mm, and SI; 3.6 mm. The Van Herk Eq values of ML; are 12.16 mm, AP; 7.11 mm, and SI; 7.28 mm. Stroom Eq. values of ML; 14.12 mm, AP; 8.39 mm, and SI; 8.71 mm. The present study revealed that the set-up errors affected the dose around the beam edges, the DVHs, V 93%, mean doses of the CTVs generally unchanged, and the dose was increased for OARs.

The accepted plan DVH for the treatment of prostate cancer patients, which verified delivering the highest dose to the tumor and the lowest dose to OAR, was shown in figure 5a. The change in the dose received in the PTV and OAR was shown in figure 5b. It was observed that the effect on the CTV was within approximately 1% and 2% on the PTV in the x-direction (Figure 5c). The displacements effect on the evaluation for OAR (33% for the femur's rectum, bladder, and left and right heads) showed a relatively small impact on rectum and bladder doses. In comparison, the displacement in the lateral direction was a 2% Gy effect on both heads of the femurs (Figure 5d).

The change in the dose received in the PTV and in OAR, which occurred due to the variation of the (y-direction), was shown in figure 6a. The effect on the CTV was approximately 1% to 2% but on the PTV was within 1% to 4% in the y-direction (Figure 6b). The displacements effect on the evaluation for OAR (33% for the femur's rectum, bladder, and left and right heads) showed a relatively small impact on rectum and bladder doses. At the same time, there was an increase and decrease (up and down) direction on both heads of the femurs (Figure 6c).

The change in the dose received in the PTV and in OAR, which occurred due to the variation of the (z-direction), was shown in figure 7a. It was observed that the effect on the CTV was approximately 1% to 4% but on the PTV was within 2% to 3% in the z-direction, as presented in figure 7b. The displacements effect on the evaluation of OAR (which was 33% for the rectum, bladder, and left and right heads of femurs) showed that there was a 4% Gy displacement effect on the rectum and bladder, while there was a 1% Gy effect on both heads of femurs (Figure 7c).

The accepted plan DVH for the treatment of bladder cancer patients is shown in figure (8a). The change in the dose received in the PTV and in OAR, which occurred due to the variation of lateral (x-direction), was shown in figure 8b. It was observed that the effect on the CTV was approximately 11.5%, but the PTV was within 2% in the x-direction, as shown in figure 8c. The displacements effect on the evaluation for OAR (which was 33% for the rectum, prostate, and left and right heads of femurs) showed that the assessment had an approximately constant effect on rectum and prostate doses because the displacement is in the lateral direction. There are no posterior fields, while there was a 2% Gy effect on both heads of the femurs (Figure 8d).

The change in the dose received in the PTV and in OAR, which occurred due to the variation of anterior-posterior (y-direction), was shown in figure 9a. The effect on the CTV was approximately 1%, but the PTV was within 3% in the y-direction, as

displayed in figure 9b. The displacement effect on the evaluation for OAR (which was 33% for the rectum, prostate, and left and right heads of femurs) showed a constant effect on both heads of femurs and prostate, while there was a 10% Gy effect on the rectum (Figure 9c).

The change in the dose received in the PTV and in OAR, which occurred due to the variation of longitudinal (z-direction), was shown in figure 10a. The effect on the CTV was approximately 1% to 3.6%, but the PTV was within 2% to 4.5% in the z-direction, as indicated in figure 10b. The displacements effect on the evaluation for OAR (which was 33% for rectum, prostate, and left and right heads of femurs) showed up and down effect on both heads of femurs and rectum but the effect on prostate was within 30% Gy (Figure 10c).

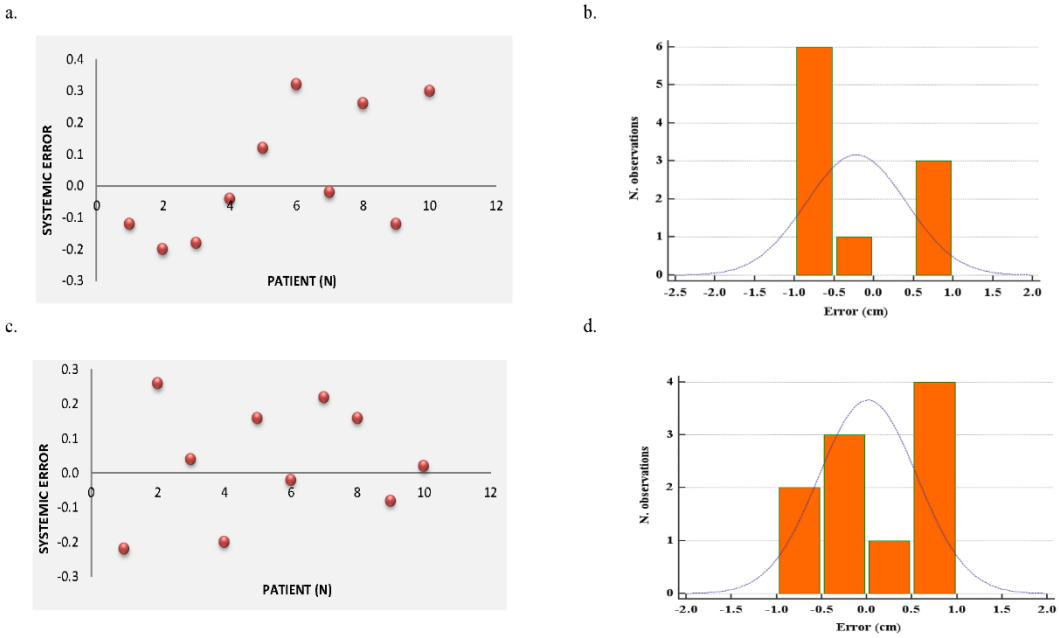


Figure 1. Systemic errors (a, c) and random errors (b, d) detected by EPID along the x-axis for prostate (a, b) and bladder (c, d) cancer patients.

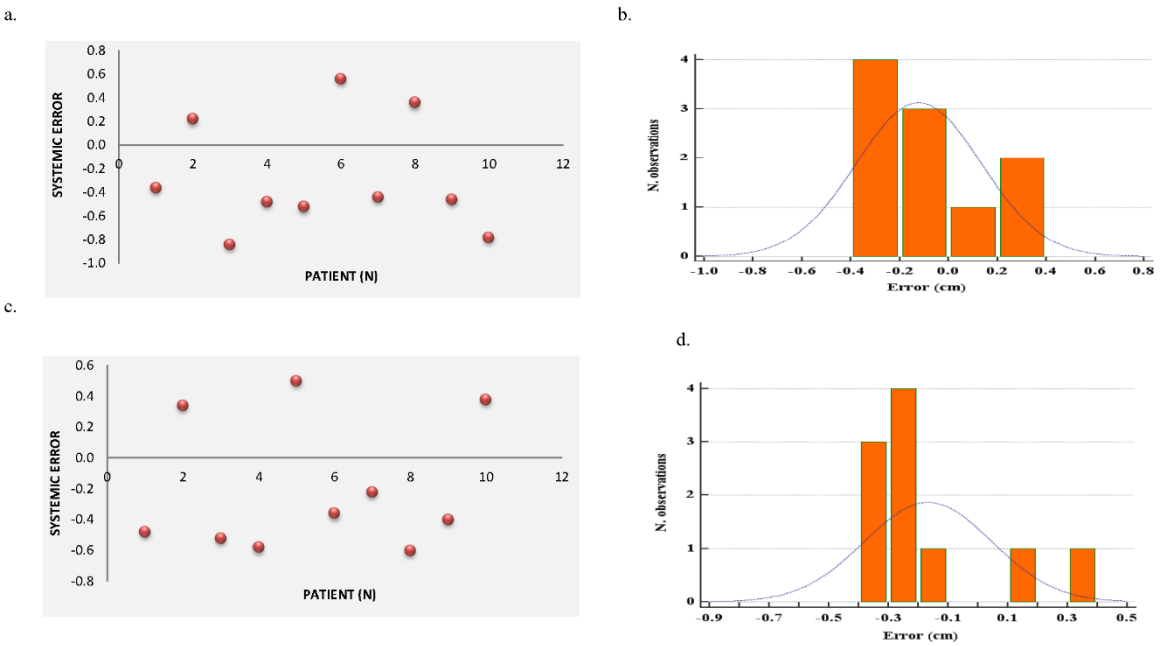


Figure 2. Systemic errors (a, c) and random errors (b, d) detected by EPID along the y-axis for prostate (a, b) and bladder (c, d) cancer patients.

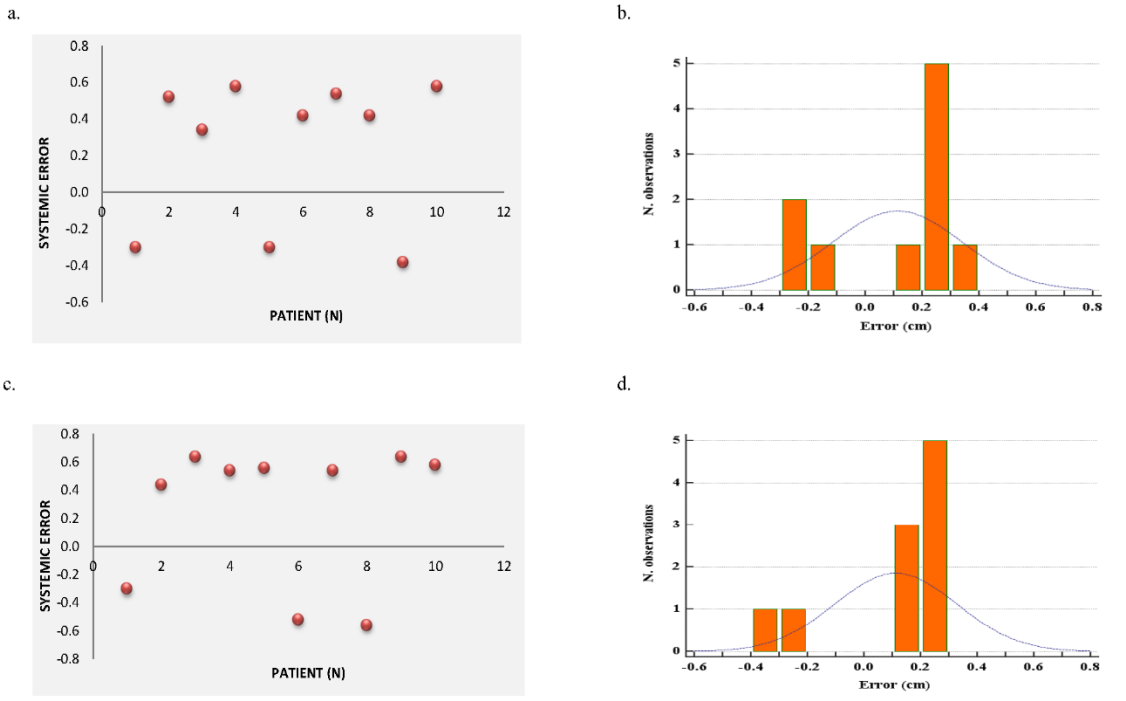


Figure 3. Systemic errors (a, c) and random errors (b, d) detected by EPID along the z-axis for prostate (a, b) and bladder (c, d) cancer patients.

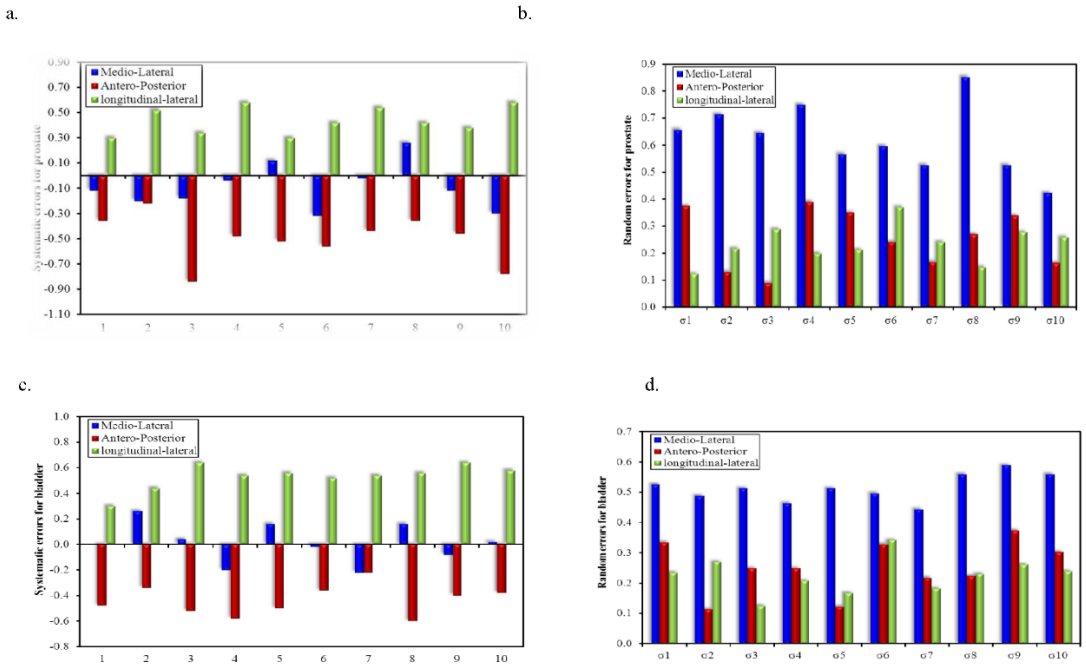


Figure 4. Scatter plot of displacements for systemic (a, c) and random (b, d) errors in all three directions for prostate (a, b) and bladder cancers (c, d).

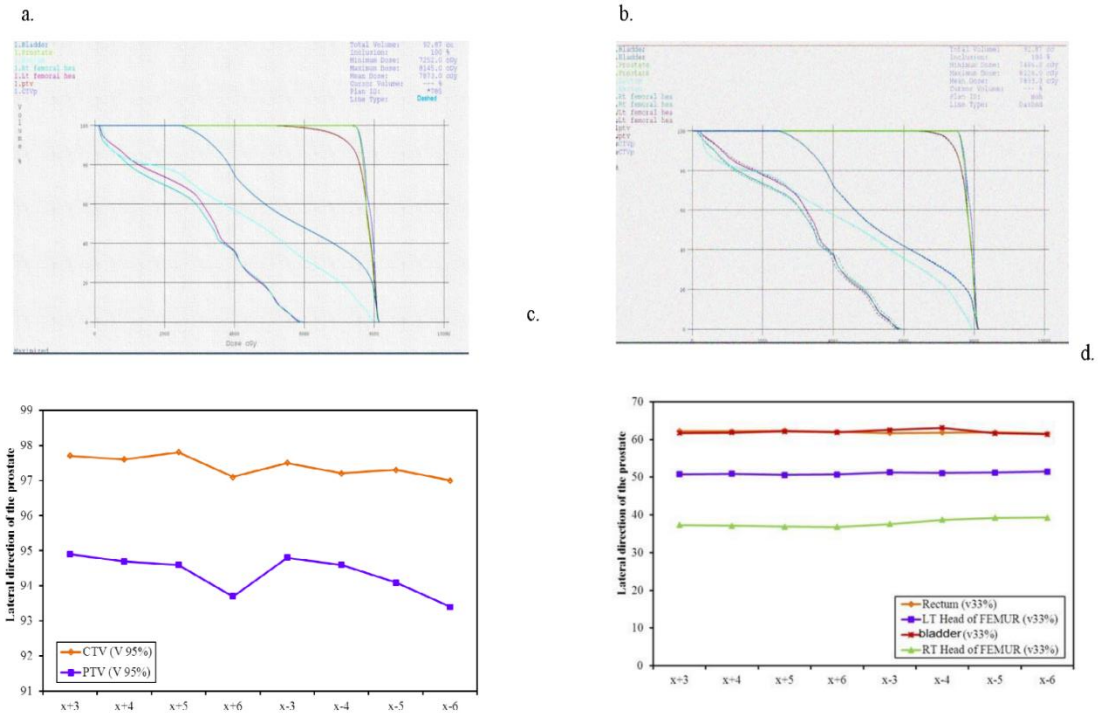
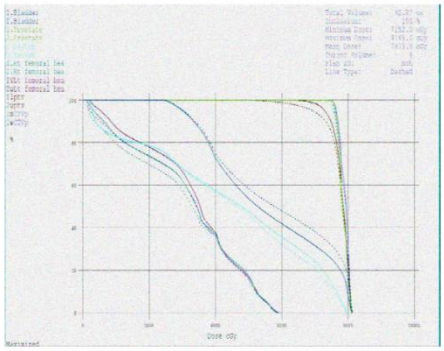
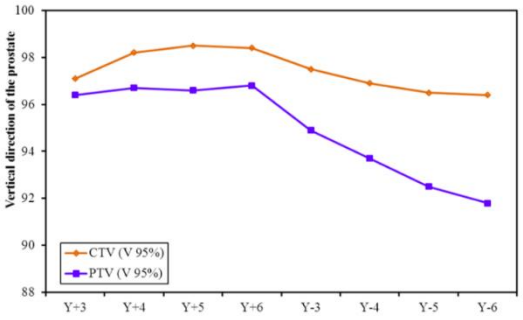


Figure 5. Accepted plan DVH for prostate cancers (a), dose change due to lateral displacement (b), and effect of set-up errors simulation on CTV-PTV margins (c), and OAR (d) in x- direction of prostate cancers.

a.



b.



c.

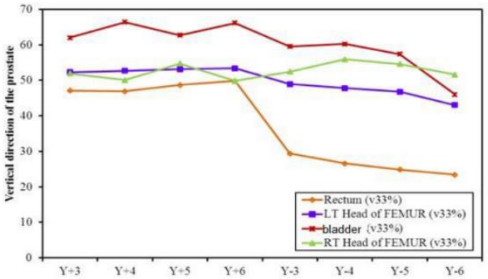
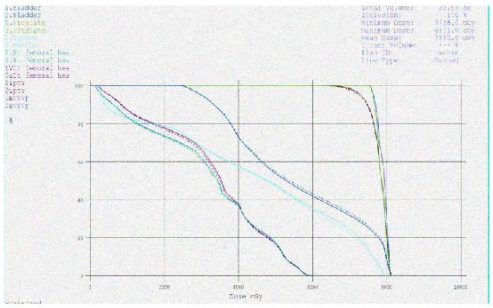
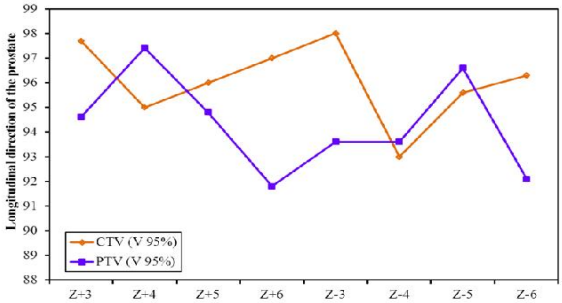


Figure 6. Dose changes due to vertical displacement (a), effect of set-up errors simulation on CTV-PTV margins (b), and effect of set-up errors OAR (c) in y-direction of prostate cancers.

a.



b.



c.

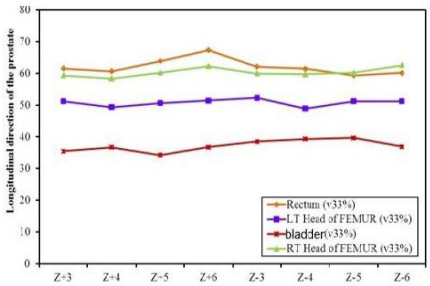


Figure 7. Dose changes due to longitudinal displacement (a), effect of set-up errors simulation on CTV-PTV margins, and effect of set-up errors on OAR (c) in z-direction of prostate cancers.

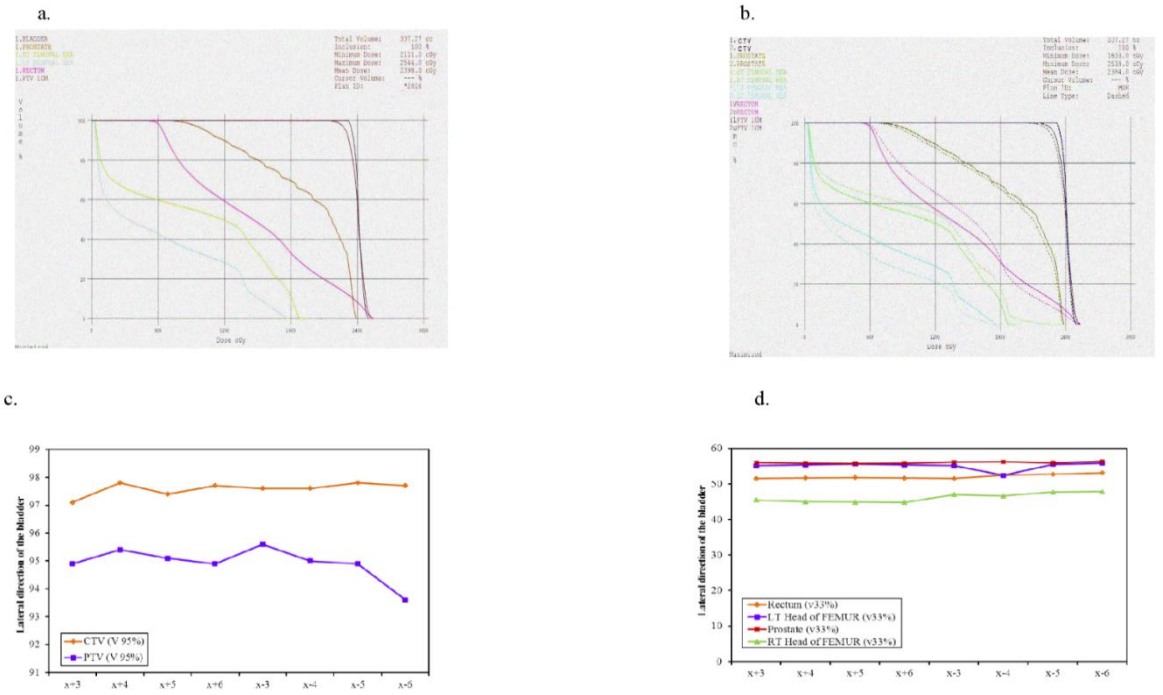


Figure 8. Accepted plan DVH (a), dose change due to lateral displacement (b), effect of set-up errors simulation on CTV-PTV margins (c). and effect of set-up errors on OAR (d) in x-direction of bladder cancers.

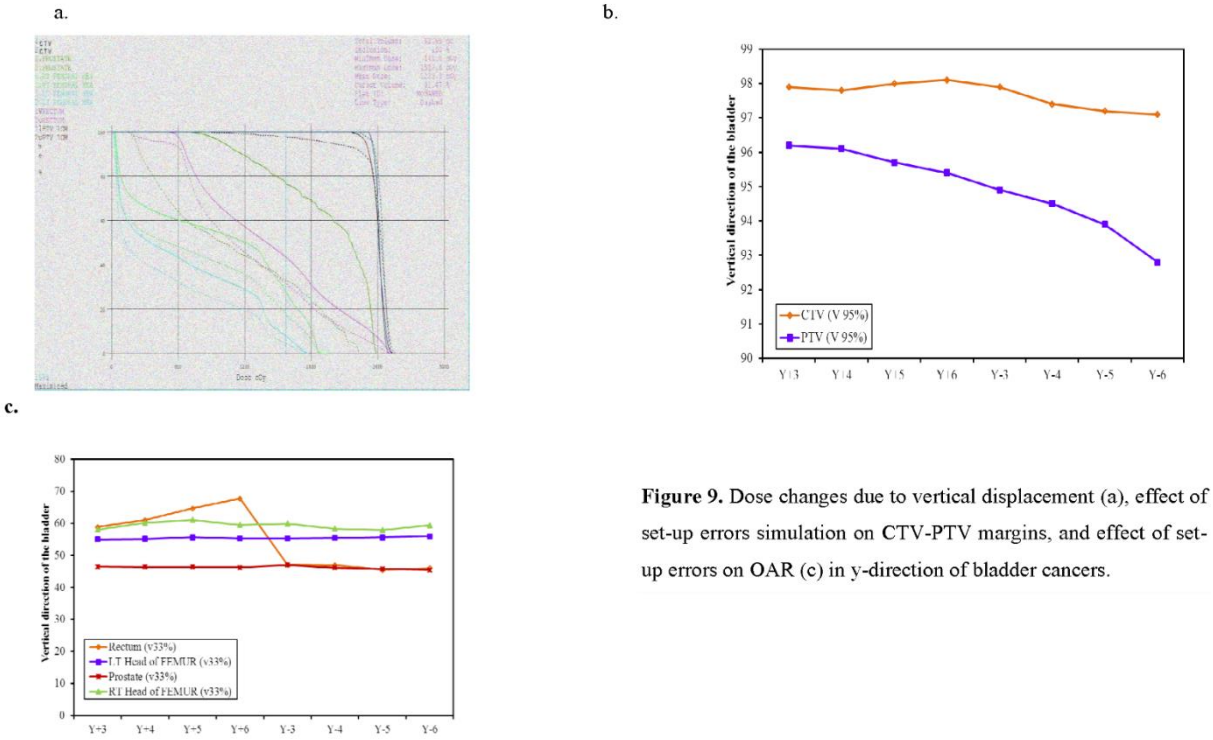


Figure 9. Dose changes due to vertical displacement (a), effect of set-up errors simulation on CTV-PTV margins, and effect of set-up errors on OAR (c) in y-direction of bladder cancers.

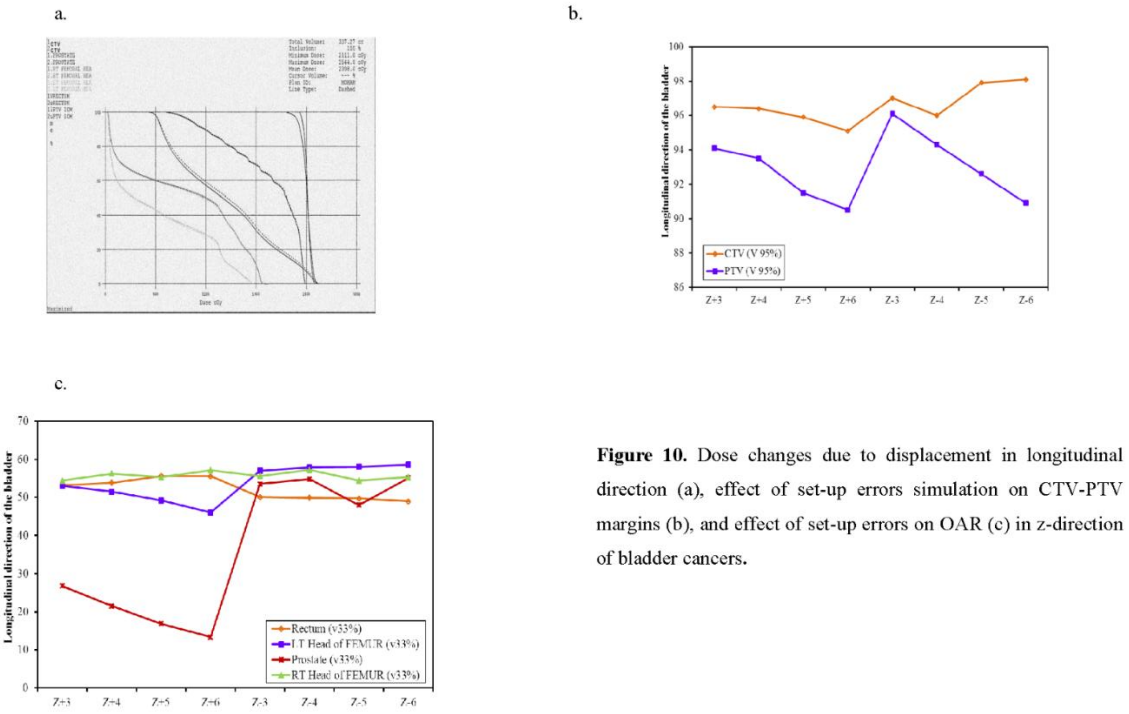


Figure 10. Dose changes due to displacement in longitudinal direction (a), effect of set-up errors simulation on CTV-PTV margins (b), and effect of set-up errors on OAR (c) in z-direction of bladder cancers.

DISCUSSION:

The current study evaluated the accuracy of the set-up and the correctness of the PTV margins used for the 3D-CRT treatment of prostate or bladder cancer Egyptian patients. Our results showed that the set-up errors influenced the dose around the beam edges. The DVHs showed that V95% and mean doses of the CTVs generally unchanged. At the same time, the dose was increased for OAR. So, each radiotherapy unit should determine the verification practices. Furthermore, we suggested acquiring pre-treatment PIs weekly to rapidly detect any variation or mistake to manage random and systemic errors effectively.

Studies planned to restrain motion and set-up of prostate and bladder are promising and prove actual advancements over matching on bony structures annotation practices. Prostate motion bends towards the anterior direction, likely because an empty rectum protocol ensures that the prostate was planned while lying in a posterior position was followed. Prostate motion was most significant at the inferior and the least at the superior positions. In addition, the bladder motion tends to be towards the anterior direction due to changes in rectal and bladder filling. However, compared to bladder filling, the amplitude of the effect of rectal filling is much lower. Set-up deviations in the three examined directions are corrected and rechecked before irradiation. These represent the intrafraction of prostate and bladder motion through the treatments. These shifts or corrections were less than the action level established in all possible directions for all 20 patients used for this study.

Several strategies and protocols were recommended to control the variation of intrapelvic organ position during RT. However, using several RT plans has the potential high risk of increasing the dosimetric uncertainties [17-20]. Daily pelvic EP imaging allows for exact dose delivery to the target, reducing the dose to

normal tissues. Recently, an integrated CT-LINAC system equipped with diagnostic-grade fan-beam CT (FBCT) as the medium of image-guided RT showed an effective reduction in the random effect caused by ionizing radiation and reduced the probability of secondary tumors [21].

Cranmer-Sargison *et al*. [22] reported that the standard deviation of random errors in prostate cancer (10 patients) was 5.4, 2.5, and 2.6 mm in x, y, and z directions, and 3.8, 2.9, and 2.8 mm for systemic errors; respectively. These values are in good agreement with our results. However, White *et al*. [23], who explored the set-up errors of sixteen patients with pelvic cancers in IMRT planning, reported a different value (SD of random errors = 2.5, 4.2, and 4.2 mm for x, y, and z directions, and 2.5, 3.9, and 3.7 mm for systemic errors). This might be due to the variation in sample number, tumor site, and the planning technique used in each study. Millender *et al*., [24] reported higher values of the positioning error in the left-right (LR) direction (median, 8 mm; range, 0–42 mm; mean, 11.4 mm/fraction) and a higher value of the mean error in SI direction (median, 5 mm; range, 0–47 mm; mean, 7.2 mm/fraction). The least problematic was the error in the Ap direction (median, 2.5 mm; range, 0–8 mm; mean, 2.6 mm/fraction).

Our results in bladder cancer agreed with those reported by Rudat *et al*., [25] who found that the systemic errors were 3.8, 2.3, and 3.2 mm for ML, AP, and SI; respectively, and random errors were 4.7, 3.2, and 2.5 mm for ML, AP, and SI; respectively. The data analysis used in this study uses an offline imaging technique and image matching that uses bone anatomy rather than the tumor to identify all set-up faults. Daily online imaging using seeds or soft tissue information is suggested to enable minimizing margins [26]. To accomplish this, expenditures on hardware and resources were necessary and it was claimed that the value of utilizing a three mm action level for offline bone anatomy-based matching would be limited. Recently, Sadeghnejad-Barkousaraie *et al*., [27] proposed a reinforcement learning strategy using Monte Carlo guided Tree Search (GTS) to find a better beam orientation set in less time than column generation (CG). Kai *et al*., [28] suggested that machine learning architectures (MLAs) with a positional difference in the upper rectal wall (as an anatomical feature) semi-automated prediction approach could be useful in the prediction of CTV shifts for prostate radiotherapy.

Both prostate and bladder cancer patients require special attention and checking on more frequently utilizing EPID due to the reported displacements. Motion is restrained by a thermoplastic immobilization device with a footrest or ankle rest.

CTV-PTV margins are produced using several mathematical formulas. ICRU 62 [14] assumes that both systemic and random errors have an equal impact on dosage distribution which is doubtful. Other formulae accounted for a differential effect using dose-population histograms and coverage probability matrices were proposed by Stroom *et al*. [15] and van Herk *et al*. [16]. EPID is a beneficial tool for a quick and accurate evaluation that is suitable for application in 3-DCRT [24]. Kasabasić *et al*. [29] reported higher values than ours for PTV margins using ICRU 62 Eq (8.9 mm, 10 mm, and 6.1 mm in ML, AP, and SI directions, respectively). However, they used a more efficient immobilization device (belly board). The position was uncomfortable, and patients were accommodated in the first few days of the therapy. Accordingly, it is essential to prepare the patient for an awkward position before the start of the TP. For rectal cancer, Mohamed *et al*., [30] recommended a PTV margin of 0.7 cm for daily and 1.0 cm no-daily IGRT. Higher PTV margins of 1.2 cm

for the prone position and 1.4 cm for BMI >30 kg/m^2 in no-daily IGRT cases. Therefore, it was suggested that every center should examine the treatment position, BMI, and fixation aids and their correlation to the setup variations and PTV margins.

Many researchers calculated the PTV margin by using Van Herk and Stroom equations. In the current study, we determined the margins for PTV for 3DCRT and prepared an offline correcting protocol for set-up errors in pelvis cancer "prostate and bladder." Van Herk *et al*. [31] defined the PTV margin as "the margin needed to ensure, in the presence of set-up and other uncertainties, that the dose to the CTV was 95% in 90% of the treated patients". Based on historical practice and clinical experience, many facilities employ an empirical PTV expansion of 5-10 mm.

A 5 mm action level proved relative advantages over a no correction protocol to control systemic set-up uncertainties, specifically in the SI-direction. However, the data suggest that lowering the action level to 3 mm would not have many advantages. This might be because a 5 mm action level was not carefully observed in practice, with systemic uncertainties of 4 mm being regularly adjusted at the doctors' discretion. However, it is crucial to consider that a 3 mm action level would increase the number of images acquired during the patient's treatment to verify a systemic deviation. It might be helpful to assess field position if pertinent stable structures to three significant axes and insert fiducial markers. Offline correction is efficient in managing the systemic component of set-up errors. Still, it has less effect on the random part. Complete removal of systemic and random errors can be accomplished by online position verification since it is a logical and feasible extension of all EPI protocols risk to benefit ratio [32].

There are few reports about the increment in treatment duration and the potential effect on workload. Chung *et al*. [33] showed that the treatment duration increases from 6.1 to 8.7 minutes if corrections are applied. In that study, no comparison was performed with controls. In our study, the treatment duration increased by 5 min from acquiring the first image to re-entering the treatment room and applying the corrections. If this were to be applied to all prostate and bladder patients, the daily workload would increase by one hour and 40 min. However, this practice will still be helpful compared to reducing normal tissue dose, especially in the rectum [11].

It is evident now that margins are inadequate and there is an international need for both improved commercial tools to control and evaluate plan complexity and robustness towards relevant uncertainties and international guidelines on how to manage plan complexity and robustness in the different steps of the RT workflow [34].

Conclusions

In conclusion, conformal radiotherapy must be performed under optimal conditions and adequate experiences, especially in new centers. For centers that can't afford integrating recent tools, we recommend that i) Patients would have five reference tattoos (one anterior to determine the LR isocenter position, two laterals aligned to each other in the AP directions to define the isocenter position, and two up and down of the anterior in the same transverse plane. The pelvic tilt should be aligned so that the anterior tattoo is within 5 mm of the lateral tattoos, ii) A portal imaging might be acquired once or twice during the first week of RT, and iii) the weight of the patient should be recorded early, iv) A simple set-up correction protocol should be applied routinely by RT technologists, v) Use of the isocenter couch distance as a set-up parameter to reduce AP set-up errors when the target area has a reasonably fixed position relative to the pelvic bones, e.g., the prostate, vii) and Proficient training of RT

technologists should be provided to develop their skills for patient positioning according to the TP periodically.

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Conflicts of interest:

Authors declare no conflicts of interest.

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تقييم الخطأ في العلاج الإشعاعي ثلاثي الأبعاد أثناء علاج المرضى المصابين بسرطان البروستاتا والمثانة في مستشفى أيادي المستقبل (الإسكندرية، مصر)

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المقدمه : يعد العلاج الإشعاعي ثلاثي الأبعاد هو الأكثر شيوعًا لعلاج سرطان البروستاتا والمثانة، لذلك يهدف البحث لتقييم الخطأ فى إعداد العلاج الإشعاعي ثلاثي الأبعاد.

الاساليب:فقد شملت الدراسة عشرون مريض (عشرة من المرضى المصابين بسرطان البروستاتا وعشرة يعانون من سرطان المثانة) ، و قد استخدمت الصور الاشعاعية المقطعية التي أعيد تنظيمها رقميا لتقديمها الى جهاز تصوير البوابة الإلكترونية اثناء خطة العلاج الإشعاعي كصور مرجعية للمقارنة مع صور البوابة الإلكترونية ،وتمت مقارنة متوسط الازاحة لجميع الصور الاشعاعية الرقمية في الثلاث محاور الرئيسية. كما تم حساب حدود حجم الهدف المخطط باستخدام تقارير اللجنة الدولية حول وحدات الإشعاع والقياسات تقرير 62 بمعادلات ستروم و فان هيرك.

النتائج: كان خطأ الإعداد 9.82 ، 8.36 مم للبروستاتا والمثانة على التوالي، وكان متوسط قيم الازاحة 7.96، 4.16، و 3.97 مم للبروستاتا و 6.59، 3.66، 3.63 مم للمثانة على طول المحاور الجانبية والرأسية والافقية على التوالي. أما بالنسبة للبروستاتا ؛ فقد كان الخطأ المنهجي 4.91 ، 3.32 ، 3.23 مم في الاتجاهات الجانبية والرأسية والافقية على التوالي،بينما كان الخطأ العشوائي فى الاتجاه الجانبى 6.2 مم ،و فى الاتجاه الرأسى 2.3 مم ، وفى الاتجاه الأفقى 2.5 مم.

و بالنسبة للمثانة ؛ كان الخطأ المنهجي فى الاتجاه الجانبى 4.1 مم ، وفى الاتجاه الرأسى 2.55 مم، وفى الاتجاه الأفقى 2.65 مم، بينما كان الخطأ العشوائي فى الاتجاه الجانبى 4.1 مم، وفى الاتجاه الرأسى مم 2.55، و وفى الاتجاه الأفقى 2.65 مم. وقد توصلنا الى أن أفضل حساب حدود حجم الهدف المخطط يتحقق باستخدام صيغة فان هيرك في جميع الاتجاهات للسرطان.

الخلاصة: يجب اتباع بروتوكولات إعداد العلاج الإشعاعي ثلاثي الأبعاد لسرطان البروستاتا والمثانة