Supine Craniospinal Irradiation In Children: Patient Position Modification, Dose Uniformity And Early Adverse Effects

M.S. Zaghloul, E. Eldebawy, E. Attalah, S. Ahmed, M. Nazmy, H. Aboel Anin

Radiation Oncology Department, Children’s Cancer Hospital, Egypt (CCHE) and National Cancer Institute, Cairo University, Cairo, Egypt

Abstract

Background:

Different craniospinal irradiation techniques are complex. The homogeneity of the dose to the target and the normal tissues at risk affect both the control rate and the level of adverse effects.

Patients and methods:

Thirty one patients were treated with CSI in the supine position. Custom-made Styrofoam was tailored for each patient to straighten the convexity and concavity of the spinal axis allowing better dose distribution uniformity during CSI technique. In the first 6 patients, CT simulation were performed twice: one time with the patient lying directly on the vacuum mattress without the foam (the conventional way) and the second while lying on the foam. Dose distribution was calculated using a 3D conformal planning. The gap between the fields was determined using isodose alignment method. All treatment portals were verified during the first 3 treatment sessions and once weekly thereafter using either cone-beam or portal image device. Weekly feathering (shifting of the junction between the 2 adjacent radiation fields) was routinely performed.

Results:

The 95% dose distribution had better coverage with the foam (p=0.042) while the hot volume of 110% and 105% dosage were significantly lesser than conventional technique (both p=0.028). The organs at risk received nearly similar radiation doses in the 2 positions. The CSI led to minimal immediate adverse effects that were reversible. Weight loss was experienced by 55% of patients.

Conclusion:

This modified technique of CSI is simple, ensuring better dose distribution to CSI target without increasing the dose to the surrounding organs at risk. It is tolerable and safe to apply.

Keywords

Craniospinal irradiation, supine, Medulloblastoma, CNS leukemia, Conformal radiotherapy, 3D-CRT, Immediate adverse effects.

Introduction

Craniospinal irradiation (CSI) is one of the most complex radiotherapeutic techniques. It is needed to cover a complex clinical target volume (CTV) including the whole brain and a considerable length of the spinal axis and their covering meninges. Modern imaging, images fusion and registration, advanced planning and radiotherapy treatment techniques offer improved treatment execution accuracy. The CSI can be performed using different methods either in prone or supine position. Prone position has the advantage of visualizing the spinal field(s) and the junction(s) between the fields. However, the potential discomfort and difficulties in anesthesia, especially for children, are considered major disadvantages. On the other hand, supine position shows more comfort to the patient and easier and safer setup for anesthesia or sedation.

Corresponding Author: Mohamed S. Zaghloul, MD, Department of Radiation Oncology, Children’s Cancer Hospital & National Cancer Institute, Cairo University, Cairo, Egypt. Tel: (20)101720664, Fax: (20)223619036, Email: mszagh@yahoo.com
The disadvantage of non-visualization of the spinal field has been overcome through different methods\(^{(2-7)}\).

Several supine techniques adjust patient position for better assessment and management of the airway especially in children. In addition, different dosimetry application have been used to minimize long-term toxicity while simultaneously delivering homogenous dose to the target volumes\(^{(4,6)}\). The spinal axis is usually covered by a single or 2 fields geometrically abutted at the target level and is (or are) calculated at a point that allows maximum homogenous planning target volume (PTV) coverage. The junction between the brain and spinal fields, the 2 spinal fields in lengthy spinal axis and the patient immobilization are important points to be considered in order to ensure reproducibility from day to day and to avoid over or under dosage of such a critical organ like the spinal cord. Some centers use a couch rotation, which adds to the complexity of treatment. An extended source skin distance (SSD) in situation when the length of spinal field exceeds 40 cm entails moving the couch upward which will add to the complexity and the uncertainty of the matching technique\(^{(8)}\).

The spine PTV dose inhomogeneity arises from the natural lordosis and kyphosis in the lumbosacral and cervicothoracic spine respectively. This normal anatomy resulted in variation in radiation dosage in different regions of the spine. The greater difference appears in the lumbosacral spine, as they are located in a longer distance away from the skin. On the contrary higher doses were delivered to the vertebral bodies at the high thoracic level, because of the shallow depth of the target structure at this point\(^{(9)}\).

The present study modification aims at allowing maximum straightening of the spinal axis and ensures mandibular position away from the divergent posterior spinal field. This modification will improve the homogeneity of the spinal PTV coverage and decrease the magnitude of unavoidable radiation to the surrounding normal tissues. This may reflect on the rate and severity of immediate side effects.

### Patients and methods

Thirty-one children were treated with CSI at Children’s Cancer Hospital, Egypt (CCHE) during the period from June 2008 and August 2009. The diagnoses of these patients were: 24 medulloblastoma, 3 central nervous system acute lymphoblastic leukemia, 2 immature teratoma, one pineoblastoma and one supratentorial Primitive Neuroectodermal tumor (PNET). These patients were treated with craniospinal irradiation (CSI) in supine position. The PTV isodose leveling and doses to different normal tissues and organs were determined.

The age of the patients ranged from 3 to 16 years (mean = 7.0± 3.6 and a median of 6 years). They were 21 males and 10 females.

All patients were treated in supine position with neck extended so as the posterior spine field could exit below the mandible. The patient’s head was immobilized with a thermoplastic mask after positioning on a suitable headrest that ensured the needed degree of neck extension. The thermoplastic mask is incorporated together with the vacuum mattress, for fixation of the rest of the patient’s body resulting in whole body fixation. A custom-made Styrofoam board was put under the patient’s chest, abdomen and chest to ameliorate the normal lordosis and kyphosis of the spine. For the purpose of testing the efficacy of Styrofoam board CT-based simulation was performed in 6 patients twice, the first allowing the patient to lie on a custom-made Styrofoam board, while the second simulation was performed without this board (conventional method). For each, a lateral CT scout view was performed to verify the position of the mandible and an anterior scout view was also used to check the spine alignment in midline.

Three radio-opaque fiducial markers were placed on the mask at the cervical vertebra to locate the plain of origin. A standard CT scanning protocol was performed starting from the top of the scale to the end of the ischium including the whole body content. Images from this scan were transferred to contouring workstation. The planning process began by identifying all borders and areas at which junctions would be automatically shifted.
The surface of the brain and the whole length of the spinal axis were carefully contoured every 4 mm, to define the brain clinical target volume (CTV). The cranial CTV (encompassing the entire brain and meninges) and the spinal CTV (encompassing the spinal canal as seen on CT extending laterally) to encompass the cerebrospinal fluid extension to the spinal ganglia as identified on CT and T2 weighed MRI.

Magnetic resonance images were used to determine the inferior border (Thecal sac) and lateral extent of the cord space. Once determined a contour was placed at the inferior aspect of the thecal sac. If the spinal field was longer than the maximal collimator jaw length (40 cm), two abutted spinal fields were used. The junction was chosen to be below the level of L2 – L3 interspace so as to avoid abutting at the level of spinal cord. If 2 fields were used, the length of the superior portion of the inferior spine field is adjusted with asymmetric jaws in order to match the inferior limit of the superior spine at the depth of the posterior surface of the vertebral body at this level.

The whole treatment volume consisted of 2 lateral cranial fields and one or 2 posterior fields for the spine resulting in a 3-field junction in the cervical region and probably spinal – spinal junction at the lumbar region in case of longer spinal field more than 40 cm.

The PTV included 5 mm margin around the CTV in all directions but not at junction areas (neither in the craniospinal, nor in the spino-spinal junction). Organs at risk (OAR) were outlined including the thyroid, heart, lungs, liver, kidneys and bowel. The whole body was identified as the external contour of the body over the whole length of the treated volume.

The reference isocenter for the brain fields is defined at mid-plane and the chosen level of the cervical vertebra at isodose planning.

Two lateral fields were used to treat the brain using half-beam block to provide a non-divergent junction with the posterior spine field (obviating the need for any couch rotation).

The PTV was adequately covered, lateral beams didn’t enter the patients through the shoulders, enough neck inferior borders was chosen to allow for junction feathering and the junction was positioned such as to minimize the exit dose through the thyroid and to avoid having the spine field exit through the mandible. A collimator rotation is used to match the non-diverging inferior limit of the brain and the diverging supine fields using the isodose match method.

The spine field isocenter was located at the same level of brain field isocenter and fulfilled the criteria mentioned above. Longitudinal motion of the couch was the only required motion, these table movements were calculated by the treatment planning system in relation to the reference point. During treatment the matching of the radiation fields was resumed by using digital couch readout. Gantry rotation and beam collimator parameters were checked.

The width of the brain fields is adjusted using the asymmetric jaws, shielding for the cranial fields was generated automatically with the auto-blocking function available with the multileaf collimators (MLC). The shielding allowed for a 5-7 mm margin to exist between the PTV and the blocks. This allowed for patients setup error, patient motion and ensured that the PTV was covered by at least the 95% isodose line when the plan is normalized to 100% at the center of the whole brain field. Pretreatment quality assurance was performed using film dosimetry to verify the match between cranial and spinal fields.

The width of the spine field(s) was adjusted using asymmetric jaws to cover the neural foramina and the field was shaped appropriately by using MLC. For the first 6 patients, 2 sets of CT images were performed for each patient, one using the custom-made Styrofoam board underneath the chest, abdomen and pelvis of the patients and the other without the foam. The CT images and data were transferred to 3D treatment planning system (Xio, CMS) and the dose distributions were calculated in each set separately. Dose calculations of the 2 situations were performed for the target (craniospinal axis) and all normal structures located near the spinal axis (Figure 1). Comparison of these calculations
Fig. 1: Anesthetized patient in set up position with combined thermoplast head fixation cast and vacuum mattress for fixation of the rest of the body. Styrofoam board was put under the chest, abdomen and pelvis of the patient.

Fig. 2a: Lateral scout with PTV delineation for both cranium and spinal fields. The isodose distribution curves were illustrated in a patients lying on Custom-made Styrofoam board
in the 2 sets were performed at different dose levels.

Portal image or cone-beam CT (CBCT) verifications were performed for all 31 patients in the first 3 treatments and once weekly thereafter until the end of therapy.

The common terminology criteria for adverse events (version 3) were used to report on CSI immediate adverse effects\(^{(11)}\).

Patients were followed up regularly according to the follow up policy of each disease. The median follow up period was 16 months (range: 11-25).

**Statistical analysis**

Data was analyzed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA) for Windows. The first step was to provide descriptive statistics such as mean and standard deviation (SD). Wilcoxon Signed Ranks Test was used to compare the difference between the measurement taken with and without foam. The level of statistical significance was set at \( p < 0.05 \).

**Results**

The spinal target volume of the CSI received a more homogenous dose distribution with Styrofoam than without foam that was statistically significant (Table 1). The mean percentage of volume covered by 95% of the prescribed dose was 95.7% in the foam group (range 94.1 – 97.6) compared to 94.3% in the group without foam (range 92.5-96.0) (\( p=0.042 \)).

The percentage volume received over doses (110% and 105 %) was much lower in the set with Styrofoam than in that without board (10.2%, 41.6% compared to 26.6% and 55%

<table>
<thead>
<tr>
<th>P</th>
<th>Without foam</th>
<th>With foam</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.028</td>
<td>105.3±0.8</td>
<td>103.3±0.8</td>
</tr>
<tr>
<td>0.249</td>
<td>119.9±5.6</td>
<td>116.7±5.5</td>
</tr>
<tr>
<td>0.917</td>
<td>71.9±9.2</td>
<td>73.0±8.1</td>
</tr>
<tr>
<td>0.042</td>
<td>94.3±1.4</td>
<td>95.7±1.4</td>
</tr>
<tr>
<td>1.3</td>
<td>26.6±17.6</td>
<td>7.7±10.2</td>
</tr>
<tr>
<td>0.028</td>
<td>55.0±12.2</td>
<td>41.6±6.4</td>
</tr>
<tr>
<td>0.463</td>
<td>129.3±12.7</td>
<td>127.6±12.4</td>
</tr>
</tbody>
</table>

Table 1: Evaluation parameter used to assess target dose coverage and homogeneity for spinal axis in first set with foam and the second set without foam.

Abbreviation : \( V_{95\%} \), \( V_{110\%} \), \( V_{105\%} \) volume of PTV receiving at least 95%, 110%, 105% of the prescribed dose respectively.
respectively). The mean lung volumes that received low dose radiation (1 Gy and 2 Gy) were slightly less with Styrofoam board application than without. On the contrary, the mean lung volume receiving slightly higher doses (5 Gy and 10 Gy) were higher with the foam than without it (although statistically insignificant). The heart, liver, bowel and kidneys received slightly higher level of doses in the low as well as the high dose levels with application of the foam, again without statistical significance (p value ranged from 0.141 to 0.977) (Table 2).

Table 2: The mean ± standard deviation of the volume of the organs at risk (Heart, Liver, Bowel, Right kidney, Left kidney, Right Lung, Left Lung and thyroid) received 1 Gy (V1), 2 Gy (V2), 5 Gy (V5) and 10 Gy (V10) as a result of delivering 23.40 Gy to the spinal PTV in patients when lying on Styrofoam board (with) and for the same patients when lying directly on the vacuum mattress (without).

<table>
<thead>
<tr>
<th></th>
<th>with</th>
<th>p</th>
<th>with</th>
<th>p</th>
<th>with</th>
<th>p</th>
<th>with</th>
<th>p</th>
<th>with</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart</td>
<td>99.4±1.6</td>
<td>96.7±2.0</td>
<td>0.555</td>
<td>80.4±1.2</td>
<td>2.2</td>
<td>60.5±13.8</td>
<td>0.752</td>
<td>66.3±11.6</td>
<td>1.7</td>
<td>58.7±13.2</td>
</tr>
<tr>
<td>Liver</td>
<td>69.9±15.8</td>
<td>67.3±11.0</td>
<td>0.753</td>
<td>35.5±10.7</td>
<td>9.1</td>
<td>33.6±5.9</td>
<td>0.6</td>
<td>27.2±8.9</td>
<td>2.2</td>
<td>26.3±5.0</td>
</tr>
<tr>
<td>Bowel</td>
<td>82.9±10.8</td>
<td>81.1±9.8</td>
<td>0.207</td>
<td>47.9±13.8</td>
<td>8.7</td>
<td>42.4±7.0</td>
<td>0.141</td>
<td>37.8±13.0</td>
<td>3.2</td>
<td>32.8±7.3</td>
</tr>
<tr>
<td>R.kidney</td>
<td>91.0±9.8</td>
<td>90.6±13.0</td>
<td>0.393</td>
<td>26.1±3.2</td>
<td>2.1</td>
<td>23.1±10.7</td>
<td>0.686</td>
<td>12.1±5.1</td>
<td>2.1</td>
<td>10.3±5.9</td>
</tr>
<tr>
<td>L.kidney</td>
<td>85.1±13.4</td>
<td>86.8±15.3</td>
<td>0.586</td>
<td>18.1±10.7</td>
<td>9.1</td>
<td>19.2±8.1</td>
<td>0.917</td>
<td>8.2±8.5</td>
<td>2.7</td>
<td>7.6±4.7</td>
</tr>
<tr>
<td>R.lung</td>
<td>74.8±13.3</td>
<td>76.6±14.2</td>
<td>0.249</td>
<td>31.2±10.5</td>
<td>8.4</td>
<td>34.0±8.8</td>
<td>0.344</td>
<td>19.8±5.0</td>
<td>2.0</td>
<td>20.8±6.0</td>
</tr>
<tr>
<td>L.lung</td>
<td>66.8±14.3</td>
<td>66.9±10.1</td>
<td>0.0</td>
<td>25.5±13.4</td>
<td>2.7</td>
<td>27.1±14.2</td>
<td>0.017</td>
<td>10.3±4.8</td>
<td>1.2</td>
<td>12.3±6.0</td>
</tr>
<tr>
<td>thyroid</td>
<td>100</td>
<td>100</td>
<td>1.0</td>
<td>100</td>
<td>1.0</td>
<td>100</td>
<td>1.0</td>
<td>100</td>
<td>1.0</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3: The mean volume in cc of unspecified tissues (non-target and non-organ at risk) with and without Styrofoam board application.

Abbreviation : V95% , V110% , V105% volume of PTV receiving at least 95% , 110% , 105% of the prescribed dose respectively

<table>
<thead>
<tr>
<th></th>
<th>Without Foam</th>
<th>With Foam</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.864</td>
<td>1.28±0.53</td>
<td>1.03±0.88</td>
<td>V110</td>
</tr>
<tr>
<td>0.944</td>
<td>2.15±0.62</td>
<td>1.92±0.83</td>
<td>V105</td>
</tr>
<tr>
<td>0.961</td>
<td>3.81±1.33</td>
<td>3.25±1.02</td>
<td>V100</td>
</tr>
<tr>
<td>0.895</td>
<td>5.77±1.57</td>
<td>5.33±1.44</td>
<td>V95</td>
</tr>
</tbody>
</table>

The heart, liver, bowel and kidneys received slightly higher level of doses in the low as well as the high dose levels with application of the foam, again without statistical significance (p value ranged from 0.141 to 0.977) (Table 2). Thyroid tissues received similar dose levels with and without Styrofoam board in the range 1-10 Gy. The same trends were also noticed in the dose levels received by unspecified tissues (tissues other than target and organs at risk). Although the radiation dose levels were slightly lower upon foam application, these differences were statistically insignificant (Table 3).

All quality assurance films showed adequate match and lack of overlap between the cranial and spinal fields (Figure 2).

**Portal imaging**

All fields were imaged and verified on a daily basis before the first 3 daily treatment sessions and once a week (at each junction change) thereafter. The portal images were compared to simulation DRRs or the cone-beam CT compared to planning CT.

![Fig. 3: Pretreatment quality assurance dosimetry film demonstrating juxtaposition of the cranial and spinal fields. The film verified the evidence of the lack of overlap between the 2 fields and matching the divergence of spinal field with the inferior border of the half-beam blocked cranial field.](image-url)
Immediate adverse events

Gastrointestinal (GIT) toxicity was experienced by 20 patients (65%). Out of these 20 patients, only 3 experienced grade III toxicity (10%). Fourteen patients (45%) suffered from vomiting GI or II, while 5 (16%) from oral mucositis. Oral mucositis was GI in 3 patients and one had GII and another developed GIII. Diarrhea (GIII) was experienced by only one patient while 2 suffered from constipations. Only 6 patients (19%) developed neutropenia. Fifty five percent (17) of our patients experienced weight loss more than 10% of their weight prior to radiotherapy. Two children had insomnia, four had moderate headache and four suffered from CNS symptoms (motor deficit, squint or nocturnal enuresis) that were transient and relieved by moderate doses of corticosteroids. Furthermore, eleven patients (35%) had difficulty stopping steroids, while another 3 had systemic infection with bone marrow suppression. These 3 children had to interrupt CSI for 4-9 days for recovery. Six patients (19%) developed recurrence during the period of follow up: Four in the brain and 2 in the spinal cord. None had relapse at the sites of field junctions (feathering).

Discussion

Craniospinal irradiation is an essential component in the curative treatment of patients with brain tumors with increased risk of leptomeningeal spread. Both the quality of radiation therapy and the accuracy of delivery have a major role in the outcome of these patients. Different CSI techniques pose several challenges due to the long target volume and the close location of several critical organs (Halpering, 1996). With the use of custom-made Styrofoam board that was specially designed for dorsolumbar spine straightening, we were able to improve the spinal cord PTV coverage (volume covered by 95% isodose line) significantly (p=0.042). This maneuver decreased the hot areas covered by both 110% and 105% in a statistically significant way (p=0.028 each) (Table 1). The modification in patients set up not only straightened the spinal axis considerably but also kept the 95% isodose coverage to the maximum (mean 95.7±1.4%). Meanwhile the volume of PTV covered by higher percentage was subsequently minimized in a significant way.

It is worth mentioning that all our patients were in the pediatric age group (3.5-16 years) with a mean age of 7.9 ± 3.9 years and a median of 6 years. About 42% of these patients (13/31) receive their radiotherapy under general anesthesia. Needless to mention that anesthesia is much safer and more feasible in supine position especially if intubation is needed. Supine position is more comfortable and better tolerable by all children, even by those who didn’t receive anesthesia. Treatment is more reproducible and both planning and treatment time were reduced as compared with other techniques that used conventional simulator and fluoroscopic adjustment of the craniospinal junction. Radiation exposure is much less for the present technique than with non CT based technique in supine position(7).

Our patients tolerated CSI well with minimal side effects (both in number and severity). These side effects were all transient and were totally relieved a short time after using medical supportive drugs. However, weight loss was found to be prevalent in 55% of our children. The same percentage (55%) was experienced by Chang et al patients who received prone CSI using photons. Those who received electron CSI had higher (86%) incidence of weight loss(12). Detailed analysis of the weight loss, its magnitude and factors affecting its occurrence in CSI and other radiotherapy techniques is currently investigated in our department.

The main disadvantage of the supine position is that it does not allow direct visual confirmation of the junction between lateral brain fields and posterior spine field(s). Adopting this modification with the recommended electronic portal images or CBCT will confirm the proper position. Portal images or CBCT assure the reproducibility of treatment during each application in accordance with the simulated treatment plan, without the need for direct light field visualization. Furthermore, these EPID and CBCT have several advantages : i) Images can be verified in real time; ii) They are intrinsically digital and can be elaborated, analyzed and
compared with approved simulator images; iii) They allow for retrospective documentation; iv) EPID and CBCT can be used as a dosimeter either for quality assurance (QA) programs or portal dosimetry\(^{(13)}\).

The concerns about structures in the exit of the spinal fields mandate performing much effort to improve the homogenous dose coverage of the spinal PTV taking in consideration neither to have hot radiation volumes in the PTV nor in the surrounding normal tissues.

It is of utmost importance to weigh the risk of radiation exposure and the dose level for the various organs outside the treatment volume. The radiation dose to the surrounding normal tissue (heart, liver, both kidneys, both lungs, thyroid and unspecified tissues) didn’t receive significant higher radiation dose with the application of the Styrofoam board (Table 3).

Panandiker et al\(^{(9)}\) compared IMRT spinal irradiation with standard conventional spinal irradiation as a part of CSI in 11 patients. They reported 7% reduction in target volume receiving 110% of the prescribed dose. Applying the custom–made Styrofoam board under the chest, abdomen and pelvis in the present study reduced the target volume receiving 110% of dose by 16.4%.

Although it is a fact that Panandiker et al\(^{(9)}\) reported much lower volume covered by 95% of the prescribed dose (87.7%) for the standard technique compared to that reported in the present study for patients without foam (94.3±1.4%), yet applying the custom–made Styrofoam board improved it significantly by 1.5% to reach 95.7 ± 1.4 %. On the other hand, Parker et al\(^{(6)}\) had V 95% coverage of 96% in their 3D planning of spinal axis compared to 100% for IMRT. The adoption of IMRT technique decreased the V 107% volume dramatically (from 38% to 3%). They concluded that both 3 D and IMRT plans were superior to the standard 2D plan with respect to both OAR and dose to non-target tissue. Clup et al \(^{(14)}\) compared conventional CSI using 2 posterior spine fields, to IMRT, using multiple field segments, in one patient. Thirty field segments were used: twelve field segments for the brain, 9 for superior spinal field and 9 for inferior spinal field. The volume of spinal cord receiving 105% and 110% of the prescribed dose was reduced via IMRT by 43% and 82% for the superior and inferior spinal fields respectively. They reported that the volume of the surrounding tissues that received 100-140 % of the prescribed dose was also reduced. With the addition of Styrofoam board under the patient’s chest, abdomen and pelvis, the homogeneity of the dose to the PTV improved approaching that of IMRT without its sophistication and lengthy time application.

Furthermore, the conventional photon plan delivered greater dose delivery to smaller volumes, but lower dose delivery to larger volumes of the organ at risk compared to the IMRT plan. This is attributed to the larger number of beam portals used with the IMRT treatment plan\(^{(15)}\). Although IMRT provides considerable normal tissue sparing compared to conventional photon for the heart and bowel, yet it provides higher doses to the lungs and kidneys. Single field spinal IMRT treatment technique offers a distinct improvement in target homogeneity at the expense of minimally increased treatment time and an increase in paraspinal dose maximum\(^{(9)}\). On the other hand, physical position of the patient in a way to straighten and lessen the normal kyphosis and lordosis of the spinal cord could improve the PTV radiation dose characteristics; significantly decrease the areas of radiation overdosage without significantly affecting the inevitable doses to the non target organs around the spinal axis. The IMRT plan has the disadvantage that it usually uses a larger number of beam angles which irradiate a larger volume of normal tissues with lower doses that may lead to higher incidence of second cancer\(^{(16)}\). The simple modification in patient position through the custom-made Styrofoam board approaches the advantageous more homogenous IMRT- PTV dose, without the mentioned IMRT disadvantages.

**Conclusion**

Simple position modification of the patients in supine CSI through lying on a custom-made Styrofoam board could improve the homogeneity
of spine PTV without affecting the dose received by the surrounding OAR. Additionally the tolerance of the patients treated via this technique was excellent with minimal immediate adverse effect. However, the weight loss problem needs further and greater attention.

References


