Original Research Article

CRANIOSPINAL IRRADIATION USING THREE-DIMENSIONAL CONFORMAL RADIOTHERAPY WITH TWO DIFFERENT PLANNING TECHNIQUES: A COMPARATIVE ANALYSIS IN SUPINE AND PRONE POSITIONS

ABSTRACT

Objectives: Craniospinal Irradiation (CSI) requires radiotherapy delivery to the entire neuraxis. It is accomplished by using multiple overlapping beams covering the large target volume, which are then matched to one another using collimation, couch rotation or beam modifications. Although modern radiotherapy techniques like Intensity Modulated Radiotherapy (IMRT) and Proton Beam Therapy (PBT) offer significant advantages in delivering CSI, yet 3-Dimensional Conformal Radiotherapy (3DCRT) remains the primarily used technique- more so in resource constrained settings.

Material and Methods: The CT simulation datasets of six patients (3 supine and 3 prone positions) were used for planning two different techniques for CSI: A) Two isocenter plan with half beam block and no collimator rotation (2iso-HB-WOC) and B) Three isocenter plan with half beam block and collimator rotation (3iso-HB-WC). Plans were compared using Dose Volume Histogram (DVH) parameters for Planning Target Volume (PTV) and Organs at Risk (OARs).

Results: Considering dosimetric parameters, the2iso-HB-WOC technique was found to be equivalent to 3iso-HB-WC technique in terms of PTV coverage and OAR doses. However, on evaluating treatment positions, the volume of hotspots ($V_{107\%}$) was significantly lesser [Mean: 141.83cc vs 243.50cc, p=0.02] with improved minimum dose (D_{min}) in PTV [Mean: 29.68Gy vs 14.49Gy, p=0.03] for supine than in prone position. Also, the maximum point dose (D_{max}) to the mandible was significantly lower in patients treated in supine position [37.0Gy vs 31.31Gy, p=0.01].

Conclusion: We suggest2iso-HB-WOC technique for delivering CSI with 3DCRT. Also, supine positioning of patients in CSI appears to be dosimetrically advantageous.

Keywords: Craniospinal Irradiation, 3DCRT, Supine, Prone, Collimation, Half-beam block

INTRODUCTION:

Brain tumors originating in the infratentorial region have a high propensity of spread via cerebrospinal fluid (CSF). Such tumors include medulloblastoma, primitive neuroectodermal tumor, ependymoma and germ cell tumors. For this group of tumors, apart from surgical excision of the primary tumor, delivering radiotherapy to the entire CSF volume in the subarachnoid space of the craniospinal axis becomes imperative to achieve better outcomes[1-4]. Craniospinal Irradiation (CSI) is a challenging technique of radiotherapy as itentails treatment of the whole brain and the entire length of the spinal cord with meninges.

CSI is preferentially delivered to patients in prone position but for cases in children who require sedation/ anaesthesia, a supine position becomes mandatory. Because of the length and irregularity of the Clinical Target Volume (CTV), multiple fields with various angles of collimation and couch rotations need to be employed in achieving target coverage adequately. The earliest reports on CSI describe the following technique: two lateral opposed fields to cover the whole brain and upper cervical spine which are geometrically matched to a direct posterior/anterior field for the lower spine extending inferiorly up to the lowerlimitofthe thecal sac[5]. This often leads to inhomogeneity at the junctions of the field borders that may cause exceedingly high doses to critical organs at risk (OAR) or cold spots over target volume that are difficult to overcome. Studies have shown that quality control of radiotherapy delivery techniques is directly associated with long term outcomes in patients undergoing CSI[6].

Various authors have described multiple techniques of CSI delivery with both conventional and conformal techniques[7-10]. Intensity Modulated Radiation Therapy (IMRT), Volumetric Modulated Arc Therapy (VMAT) and Tomotherapy techniquesappear to offer superior tumour coverage with maximum sparing of the OARs in CSI[11-13]. There is also the emerging role of Proton beam radiotherapy in delivering CSI[14,15]. But most of these advanced treatment techniques are not available in resource constrained regions like India, therefore, 3-Dimentional Conformal Radiotherapy (3DCRT) treatment remains the technique of choice for CSI planning.

In this study, our aim was to analyse the dosimetry of target volume coverage and OAR doses by 3DCRT for CSI. The primary objective was to compare two different planning techniques of 3DCRT using varying isocenter positions, half beam blocks and collimator rotations. The secondary objectivewas to determine any difference in 3DCRT dosimetry in CSI with regards to treatment positions- prone versus supine.

MATERIALS AND METHODS:

The Computed Tomography (CT) datasets for radiotherapy planning of 6 patients who received Craniospinal Irradiation for treatment of Posterior Fossa Brain Tumorbetween 2016-2019 and archived in the Department of Radiation Oncology, Dr. B. Borooah Cancer Institute were utilized for this study. The study was reviewed and approved by the Institutional Ethics Committee, Dr. B. Borooah Cancer Institute.

The beam arrangement for covering the target volumes for each patient were designed using two different techniques- A) Two isocenter plan with half beam block and no collimator rotation (2iso-HB-WOC) and B) Three isocenter plan with half beam block and collimator rotation (3iso-HB-WC). For the purpose of comparison based on treatment positions, planning CT scans of 3 patients in Head First Supine (HFS) and 3 patients in Head First Prone (HFP) positions were selected. Thus, twelve 3DCRT plans (denoted by n) for the six patients (denoted by N) were generated as follows:

-In the supine position (N=3): 2iso-HB-WOC (n=3) vs. 3iso-HB-WC (n=3)

-In the prone position (N=3): 2iso-HB-WOC (n=3) vs. 3iso-HB-WC (n=3)

All the patients were immobilized using thermoplastic masks for the head and neck and vacuum cushion (Vac-Lok^{TM}) for the rest of the body as described by Lee et al.[16] Planning CT images were obtained from the vertex to the mid-thighs in Philips Brilliance big bore CT Simulator using 3mm slice thickness. Contouring of target volume was done in accordance with the guidelines published by Ajithkumar T. et al.[17] The Clinical Target Volumes for the brain and spinal cord were delineated separately- CTV_brain and CTV_spine respectively. Planning Target Volumes (PTV) were generated by uniform geometric expansion of 5 mm on the respective CTVs. Organs at Risk (OARs) contoured included parotid glands, oral cavity, mandible, larynx, thyroid gland, heart, bilateral lungs, esophagus, liver, kidneys and bowel bag.

Dose prescribed to the PTV for all plans was 36Gy in 20 fractions. Treatmentplanning was done in Eclipse (Version 15.5, Varian Associates, Paulo Aulto, CA)Treatment Planning System (TPS) with Analytical Anisotropic Algorithm (AAA) dose calculation algorithm for 6MV photon beam. The details of the two different planning techniques used are as explained below:

A) ***Two isocenter plan with half beam block and no collimator rotation (2iso-HB-WOC):*** The first isocenter for the brain field was placed at mid-plane and mid-line at the level of upper cervical vertebral body (between C2-C4). Bilateral fields for the brain were used with the beam half blocked at the isocenter (Y1= 20cm, Y2= 0 cm). No collimator rotation in the brain field was used and the oral cavity and mandible were shielded using multi-leaf collimators. Next, using the same isocenter the gantry was then rotated to deliver a direct posterior beam to the upper part of PTV_spine (Y1= 0 cm, Y2= 17 cm)-- this obviated the need for collimator rotation in the brain field as there was no junction overlap. The lower part of the PTV_spine was treated with a second spinal field with the second isocenter placed at mid-plane and mid-line. The divergence of the inferior spine field was matched to that of the upper spine field with adequate gaps between the fields. The beam arrangements for two cases (one HFS, another HFP) with this 2 isocenter plan is shown in Figure 1.

B) ***Three isocenter plan with half beam block and collimator rotation (3iso-HB-WC):***The first isocenter was placed similar to that in the 2 isocenter plan (2iso-HB-WOC) but the bilateral cranial fields were collimated to account for the divergence of the upper spinal field in this technique. The second isocenter was placed 20 cm below the first one at mid-plane and mid-line and a direct posterior (for HFS) / anterior (for HFP)beam was placed to cover the maximum possible length of the spine. In order to overcome the overlap at the neck region due to beam divergence of the brain fields and the upper spinal field, the brain fields had to be collimated accordingly. Lastly the third isocenter was placed at the same level as the others, in order to treat the remaining portion of the lower spine with a direct posterior (for HFS) / anterior (for HFP) beam. The divergence of the spinal fields were also matched accordingly with adequate gaps in between. The beam arrangements for two cases (one HFS, another HFP) with this 3 isocenter plan is shown in Figure 2.

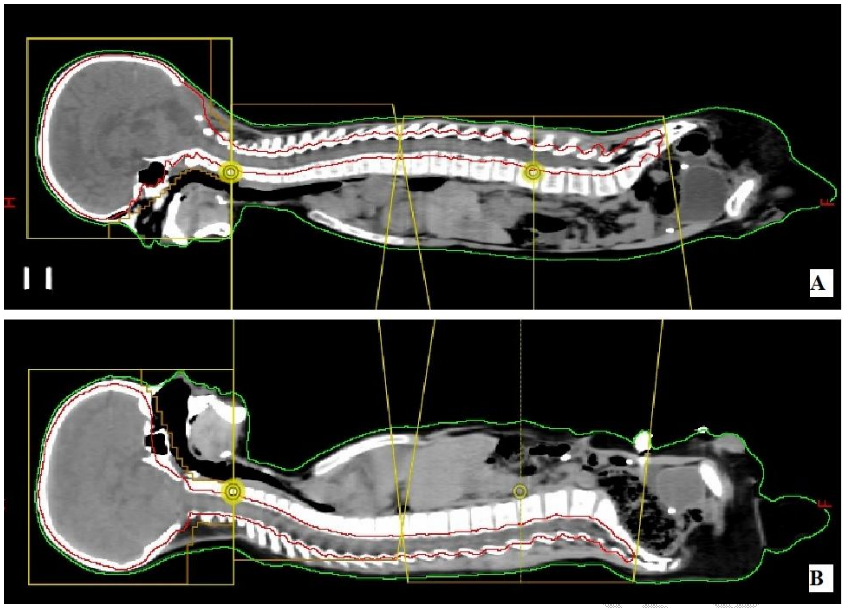

FIGURE 1: Beam arrangements for the two isocenter plan with half beam block and no collimator rotation (2iso-HB-WOC) for two different patients: one in Head First Prone (A) and the other in Head First Supine (B) positions

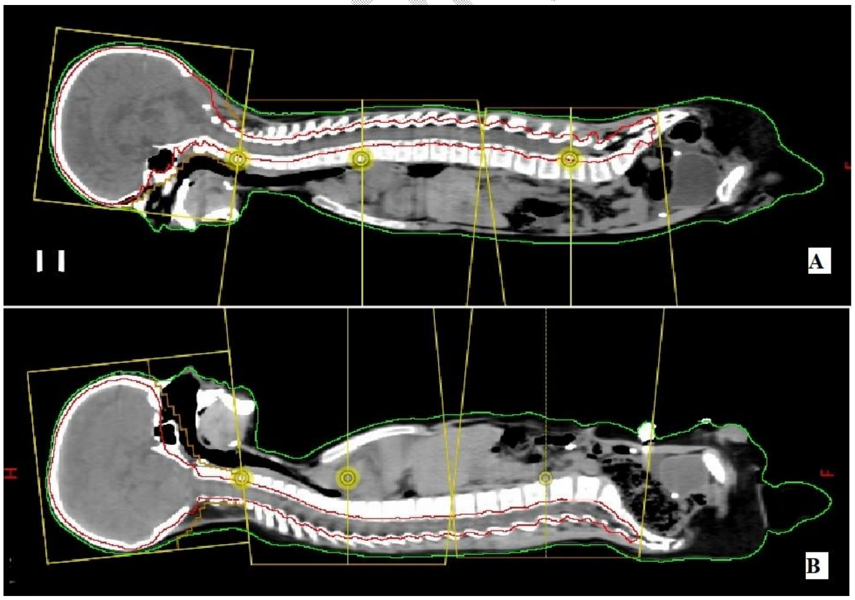

FIGURE 2: Beam arrangements for the three isocenter plan with half beam block and collimator rotation (3iso-HB-WC) for two different patients: one in Head First Prone (A) and the other in Head First Supine (B) positions

The gap at the junction of the lower border of the upper spinal field with the upper border of the lower spinal field was kept at 0.5- to 1-cm or use was made of the formula: Gap (G)= ½ L1 (d/SSD) +½ L2 (d/SSD), where L1 is the length of the upper spinal field, L2 the length of the lower spinal field, d is the depth at which field matching is being considered, and SSD is the source-skin distance.All the plans were planned with Source to Axis Distance (SAD) technique. Fields were shaped according to the three-dimensional shape of the PTV brain and spine using multi-leaf collimators (Millenium 120). For PTV_brain, dose was prescribed and normalized at the geometric center of the target while the spinal fields were weighted to obtain optimum coverage of the PTV_spine. However, for the purpose of plan evaluation, both the brain and spine PTVs were combined to generate a combined PTV.

Adequate feathering of the junction hotspots had to be implemented using asymmetric jaws in both the planning techniques. The 2iso-HB-WOCtechnique had only one field junction between the upper and lower spinal fields. In the 3iso-HB-WC,however, there were two field junctions- one at the lower border of the collimated cranial field and the divergent upper spinal field and the other in between the two spinal fields. The field junctions between the spinal fields (in both techniques) and that between the cranial and upper spinal field (in the 3iso-HB-WC) were shifted cranio-caudally by increasing the length of the upper field and concurrently reducing the length of the lower field by 1 cm each (using respective Y jaws). This was done after every 5 fractions (9 Gy) and a composite plan for all the planned fractions was generated thereby simulating the actual treatment of each patient evaluated.

All plans were compared qualitatively and quantitatively by assessing the Dose Volume Histogram (DVH) parameters. Parameters evaluated for target volume coverage were:

A) **Volume of the PTV receiving 95%** of prescribed dose **($V_{95\%}$)**
B) **Volume receiving 107%** of prescribed dose **($V_{107\%}$)**
C) **Mean (D_{mean}), Minimum (D_{min})** and **Maximum (D_{max})** dose received by PTV
D) **Dose Homegeneity Index (DHI)** which is the ratio between dose received by 95% to 5% of PTV- i.e. D_{95}/D_5
E) **Conformity Index (CI)** as defined by Paddick et al[18] as follows:
$CI = TV_{PIV}^2 / (TV \times PIV)$, where TV_{PIV}= volume of target covered by prescription isodose, TV= volume of target and PIV= prescription isodose volume

For OARs, the mean doses (D_{mean}) were analyzed and compared between plans for the parotids, thyroid, heart, larynx and kidneys. For the mandible and bowel bag, the maximum dose received (D_{max}) were evaluated for comparison. For bilateral lungs, comparison between plans were made based on the volumes receiving 20 Gray (V_{20}) and 5 Gray (V_5) as they are known to correlate with acute and late lung toxicities, respectively.

Data were evaluated using GraphPad InStat software. The Mann-Whitney test was used for test of significance. Statistical significance was considered when p-value<0.05.

RESULTS:

The median length of the combined PTV (brain and spine) for the study cohort was 60.85 cm (Range: 47.2-70.5 cm). The DVH parameters related to Target Volume and OAR dose with respect to planning techniques used (2iso-HB-WOC vs 3iso-HB-WC) is summarized in Table 1 and those with respect to patient's treatment position (HFS vs HFP) are shown in Table 2.

TABLE 1: Target coverage and Organs at Risk doses with regards toPlanning Techniques (2iso-HB-WOC versus 3iso-HB-WC)

		Planning Technique		
	Parameters	2iso-HB-WOC	3iso-HB-WC	*P* value (Mann-Whitney)
Target (PTV)	$V_{95\%}$ (SD)	99.4 (0.75)	99.33 (0.77)	0.68
	$V_{107\%}$ (SD)	171.5 (61.0)	213.83 (84.5)	0.39
	D_{mean} (SD)	37.08 (12.4)	37.19 (19.7)	0.15
	D_{max} (SD)	45.35 (11.6)	45.69 (21.3)	0.69
	D_{min} (SD)	21.81 (10.9)	22.36 (11.2)	0.82
	DHI (SD)	0.91 (0.02)	0.89 (0.03)	0.57
	CI (SD)	0.57 (0.08)	0.58 (0.07)	0.82
OARs	Parotids- D_{mean} (SD)	25.1 (2.8)	23.5 (4.8)	0.94
	Mandible- D_{max} (SD)	34.1 (5.5)	33.9 (5.5)	1.00
	Thyroid- D_{mean} (SD)	30.0 (0.9)	30.5 (1.1)	0.57
	Heart- D_{mean} (SD)	21.6 (3.3)	22.8 (3.7)	0.59
	Larynx- D_{mean} (SD)	17.7 (7.1)	21.0 (6.7)	0.48
	R. Lung- V_{5Gy} (SD)	31.73 (15)	36.56 (15.1)	0.31
	R. Lung- V_{20Gy} (SD)	18.27 (11.8)	21.41 (11.8)	0.52
	L. Lung- V_{5Gy} (SD)	22.87 (11.1)	24.41 (12.9)	0.82
	L. Lung- V_{20Gy} (SD)	11.59 (8.0)	11.77 (9.4)	0.87
	Kidney- D_{mean} (SD)	6.9 (3.8)	7.4 (3.6)	0.82
	Bowel- D_{max} (SD)	36.3 (2.9)	35.7 (2.9)	0.69

PTV: Planning Target Volume, OAR: Organ at Risk, HFS: Head First Supine, HFP: Head First Prone, SD: Standard Deviation, $V_{95\%}$: PTV volume covered by 95% prescription isodose (in %), $V_{107\%}$: Volume covered by 107% prescription isodose (in cm^3), D_{mean}: Mean dose, D_{max}: Maximum dose, D_{min}: Minimum dose, DHI: Dose Homogeneity Index, CI: Conformity Index, V_{5Gy}: Volume of organ receiving 5 Gray (in %), V_{20Gy}: Volume of organ receiving 20 Gray (in %).

TABLE 2: Target coverage and Organs at Risk doses with regards toPatient Position (Supine versus Prone).

		Patient Position		
	Parameters	HFS	HFP	*P* value (Mann-Whitney)
Target (PTV)	$V_{95\%}$ (SD)	99.67 (0.17)	99.06 (0.95)	0.41
	$V_{107\%}$ (SD)	141.83 (57.6)	243.50 (49.1)	**0.02**
	D_{mean} (SD)	37.08 (15.4)	37.18 (17.9)	0.52
	D_{max} (SD)	44.94 (13.8)	46.11 (18.0)	0.33
	D_{min} (SD)	29.68 (2.3)	14.49 (10.0)	**0.03**
	DHI (SD)	0.91 (0.02)	0.89 (0.03)	0.33
	CI (SD)	0.57 (0.06)	0.59 (0.09)	0.59
OARs	Parotids- D_{mean} (SD)	22.64 (4.6)	26.0 (2.2)	0.24
	Mandible- D_{max} (SD)	31.31 (6.8)	37.0 (0.2)	**0.01**
	Thyroid- D_{mean} (SD)	30.7 (1.33)	29.9 (0.4)	0.42
	Heart- D_{mean} (SD)	22.6 (4.2)	21.8 (2.6)	0.69
	Larynx- D_{mean} (SD)	22.8 (6.7)	16.3 (5.6)	0.09
	R. Lung- V_{5Gy} (SD)	37.93 (18.6)	30.58 (8.0)	0.59
	R. Lung- V_{20Gy} (SD)	22.67 (14.6)	17.25 (5.5)	0.69
	L. Lung- V_{5Gy} (SD)	20.54 (15.6)	27.18 (6.4)	0.39
	L. Lung- V_{20Gy} (SD)	9.01 (11.2)	15.14 (4.5)	0.38
	Kidney- D_{mean} (SD)	8.97 (3.4)	5.7 (3.2)	0.18
	Bowel- D_{max} (SD)	37.3 (2.6)	34.7 (2.6)	0.24

PTV: Planning Target Volume, OAR: Organ at Risk, HFS: Head First Supine, HFP: Head First Prone, SD: Standard Deviation, $V_{95\%}$: PTV volume covered by 95% prescription isodose (in %), $V_{107\%}$: Volume covered by 107% prescription isodose (in cm^3), D_{mean}: Mean dose, D_{max}: Maximum dose, D_{min}: Minimum dose, DHI: Dose Homogeneity Index, CI: Conformity Index, V_{5Gy}: Volume of organ receiving 5 Gray (in %), V_{20Gy}: Volume of organ receiving 20 Gray (in %).

The various parameters of target coverage for the two different planning techniques did not reveal any significant difference between them (as shown in Table 1). Also, both the planning techniques achieved similar dosimetry to OARs like parotids, mandible, thyroid, larynx, heart, lungs, kidneys and small bowel. Our results suggest that the 2iso-HB-WOC technique is equivalent to 3iso-HB-WC in terms of PTV coverage and OAR sparing.

The 6 plans made for patients treated in Supine position (HFS), werethen compared to the 6 plans in Prone position (HFP) as shown in Table 2. A significant reduction in volume of hotspots ($V_{107\%}$) [Mean: 141.83 cc vs 243.50 cc, p=0.02] and improved D_{min} in PTV [Mean: 29.68Gy vs 14.49Gy, p=0.03] was noted for supine plans. The other parameters like D_{mean}, D_{max}, $V_{95\%}$, Conformity and Homogeneity indices did not differ significantly with respect to patient position. The parameters for OARs evaluated also did not reveal any significant difference between treatment positions- except for the mandible, where the D_{max} was significantly reduced [37.0Gy vs 31.31Gy, p=0.01] for patients in HFS position as compared to HFP position (Table 2).

DISCUSSION:

Craniospinal irradiation poses one of the greatest hurdles to radiation oncologists, medical physicists andradiation therapists owing to its complexities from simulation to planning to treatment delivery. The challenges are manifold and require meticulous planning for an effective CSI treatment delivery.

First of all, a large target volume that extends from the vertex to the sacrum often makes immobilization, patient positioning and reproducibility of treatment setup difficult. Prone positioning of patient for simulation and treatment is easier to plan multiple overlapping fields and also for the therapistsat setup to visually verify the field junctions before each treatment. However, as most of the patients undergoing CSI belong to the paediatric age group and some of whom even require sedation or general anaesthesia for treatment, prone position of treatment is often not feasible. Various authors have suggested multiple simple techniques of delivering CSI in the supine position[7-9]. In our study results, we found that planning CSI for patients in the prone position resulted in significantly greater volume of hotspots (higher $V_{107\%}$) and lower minimum doses to the PTV (lower D_{min}) than those treated in supine position. When sparing of OARs was concerned, the mandible received higher maximum dose (D_{max}) in patients treated prone which is likely due to the inability to achieve adequate extension of the neck in the prone position resulting in excess dose to the mandible by the divergence of the upper spinal field. Thus, CSI in supine position is not only more comfortable and favourable for paediatric patients requiring sedation during treatment, but also appears dosimetrically superior to that in the prone position.

The second challenge that presents in CSI is the complex and irregularly shaped clinical target volume that requires multiple field arrangement for coverage in conventional or 3DCRT techniques. Two bilateral fields for cranial target volume are matched with one or two spinal fields depending on the length of the spinal length. This results in development of field junctions which warrants adequate collimator rotations of the cranial fields and couch rotations to match the divergence of overlapping fields and overcome dose inhomogeneity at the junctions[10]. Such field arrangements require meticulous planning as well as careful setup during treatment delivery- without which serious hot or cold spots may develop over the target volume. To overcome this problem, the dosimetric advantage of Intensity Modulated Radiotherapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT) were utilized for planning CSI by Studenski et al[11]. They reported that IMRT and VMAT techniques provided better homogeneity in target coverage while reducing doses to multiple OARs than traditional technique. But it was at the cost of longer treatment times and increased low dose spillage that resulted in higher integral doses than 3DCRT. They suggested that the most clinically feasible technique for CSI is to use opposed lateral 3DCRT beams for the cranial portion of the PTV and IMRT beams for the spinal portion of the PTV to balance optimum dosimetry with minimum treatment time. Also, the high-dose delivery complexity of using IMRT for CSI, demands three-dimensional dosimetry for verificationof irradiation with Optical CT and radiochromic gel dosimeter as shown by da Silveira et al.[19]The safety and efficacy of IMRT for CSI delivery have been demonstrated in a retrospective review of 34 patients by Ahmed et al.[20] They employed hybrid forward and inverse planned IMRT for CSI in supine position and reported no isolated recurrences or myelopathies at CTV margins or field gradients over a median follow up period of 59.4 months.

Schiopu et al evaluated Helical Tomotherapy (HT) based IMRT planning for CSI and reported that compared to conventional techniques HT-based IMRT avoided gaps and junctions, spared OARs better and provided superior and more homogeneous dose distribution and target volume coverage[12]. Sharma et al. also reported similar dosimetric advantages for Tomotherapy compared to Linac based IMRT and 3DCRT for high precision CSI treatment[13]. However, they also mention that the longer beam on time with Tomotherapy raised concern regarding the intrafraction motion and higher integral doses. Recent evidence on Proton beam therapy for CSI suggest the best outcomes with OAR sparing and prevention of potential side effects while providing equal tumour control[14]. The biggest advantage with proton beams is its low integral dose compared to photons that offer maximal clinical gain for developing normal tissue of paediatric patients and decrease chances of radiation induced second primary cancers[15]. However, although these modern techniques of radiotherapy seem lucrative for CSI, yet due to their high cost and limited availability, patients in developing nations often do not get access to them. Resource constrained centers in developing countries continue to employ 3DCRT and even conventional 2-dimensional planning techniques routinely to treat patients with CSI.

Biltekin et al has recently shown that use of a novel inverse optimization based 3DCRT (i3DCRT) technique solves the issues associated with beam matching and field junctions in CSI when compared to forward planned 3DCRT (f3DCRT).[21] i3DCRT plans provided superior homogeneity and conformity than f3DCRT plans with pronounced dose reductions to esophagus and heart. The results of dose distributions with i3DCRT were comparable to IMRT in their study, with a lower total monitor unit per fraction. Munshi et al has suggested a very convenient technique that can be planned in a conventional simulator based on bony landmarks[22]. The issue of accurately measuring the divergence of the upper border of the spinal field at its junction with the lower border of the cranial field has been overcome by strategic placement of 4 radio-opaque markers in the neck of the patient at the time of simulation. This helped in exact determination of collimation of the cranial fields and the planned posterior spinal fields treated through the table could be easily set up anteriorly. Junction shifts could be implemented by simply increasing and decreasing the approximated field borders by 1cm. This technique is very handy and practical for resource constrained centers without a CT simulator.

For facilities where CT simulation or virtual simulation are available, the technique described by Parker et al. appears appropriate[7]. In our study, we have adopted a similar simulation and planning techniques using the Eclipse planning system (Version 15.5). They also used CT simulation with fixed field parameters using a 2 isocenter planning and treatment delivery. The isocenter for the brain field was placed at C2 level with lower half of the length of the field asymmetrically half-blocked at the isocenter, to eliminate the requirement of couch rotations. They had to employ 11 degree of collimator rotation to match the inferior limit of the lateral portals for brain fields with the divergent superior border of the posterior spine field. In comparison, in our 2 isocenter plan (2iso-HB-WOC), we used the isocenter placed between C2-C4 level to deliver lateral portals for PTV brain and posterior portal for upper part of PTV spine using half beam block with asymetric jaws, alternately along the length of the field. Thus, no collimator rotation had to be employed in this case for brain fields and also there was no need of employing any weekly junction shifts at the level of the upper isocenter due to a perfect isocentric matching of the fields. Comparatively, our technique is simpler as it does not require either couch or collimator rotation for any of the fields and will be easier to setup for therapists, as it entails only a single longitudinal couch motion from one isocenter to the next.

As seen in our results, the use of 3 isocenter for 3DCRT treatment planning does not offer any dosimetric advantage compared to the 2 isocenter technique for CSI. In the 2iso-HB-WOC technique, the couch needs to be moved only once in the longitudinal direction, the number of daily imaging for patient setup is lesser and weekly junction shift at only a single location is sufficient. Compared to the 3iso-HB-WC plan, the 2iso-HB-WOC technique will thus result in significant reduction in treatment delivery time. However, as our study is a retrospective dosimetric analysis of previously treated patients only, hence we could not conclusively compare the beam on time and overall treatment time for the two techniques evaluated.

Although this is not a study comparing the treatment plan in the prone versus supine position by CT simulating the same patient in different postures, yet we believe it is reasonable to draw conclusions through comparison of the six different plans in each position as a secondary objective of the study. In this regard, treatment in the supine position has been shown to be better both in terms of target coverage and OAR sparing in our study results. Supine positioningallows proper airway management and grants more comfort to the patient resulting in better neck positioning and superior shielding of the mandible and oral structures- a factor that might have resulted in lower dose (Dmax) to the mandible for supine patients in our study results (Table 2). From our institutional practice too, we have realized that treating CSI patients in the supine position with 2 isocenter planning and setup is superior, more precise and comfortable for patient and therapist alike.

CONCLUSION:

Craniospinal Irradiation is a complex radiotherapy technique that requires meticulous planning and delivery for better patient outcomes. 3DCRT technique remains the mainstay of CSI planning in most of the radiotherapy centers in resource constrained regions like India. We suggest a technique of CSI using 3DCRT with fixed field parameters using 2 isocenters employing half beam block without collimation of brain fields (2iso-HB-WOC), preferably in the supine treatment position. We believe this technique is more comfortable for patients as it requires less time for patient setup, daily imaging guidance and weekly junction shifts- thereby improving treatment accuracy while also increasing the patient throughput in busy radiotherapy departments.

ETHICAL APPROVAL: Obtained from Institutional Ethics Committee, where this study was carried out.

CONSENT: Consent waived off by Institutional Ethics Committee, as this a retrospective dosimetric evaluation of previously treated patient datasets.

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