A New Technique for Whole Craniospinal Irradiation (WCSI)

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To irradiate the entire neuroaxis, bilateral parallel opposed brain fields and direct posterior spinal field have been utilized and radiation dose at the junction between abutting fields has been extensilvely studied. And several workable methods were reported to achieve uniform dose at a desired depth at the juction between abutting fields whose central axis are coplanar. But the dose distribhution at the juction of orthogonal fields has been a persistent problem in radiation oncology. Author describes a new method to solve the junction problem between abutting fields whose central axis are orthogonal. Author utilized split beam/comllimator rotation or collimator/ couch rotation to avoid hot or cold spots that may arise from beam divergence. Author achieved accurate and homogeneous dose distribution by mathching the 50% isodose line at the junction between orthogonal central axis beam fields.

Key Words: WCSI, Junction, Technique

INTRODUCTION

Radiotherapy to the entire craniospinal axis has been employed in the treatment of medulloblastoma, germinoma, CNS lymphoma, meningeal leukemia and other mlignant brain tumors with a positive CSF cytology with or without gross spinal subarachnoid implants. Current recommendation for WCSI is to irradiate whole brain and spinal canal simultaneously on megavoltage equipment, using bilateral parallel opposed brain fields and direct posterior spinal fields with proper skin gaps. There have been intensive investigation by several authors to achieve a uniform dose at the junction between abutting fields and they report interesting workable methods to achieve a uniform dose at a desired depth at the junction by calculating the skin gap between coplanar fields or by adjusting field direction to arrive at a uniform dose at a desired depth in the region of the junction (1~4). Those suggested methods are only applicable for the beams whose central axis lie in the same plane.

Here author presents radiotherapy procedure for WCSI at Asn Medical Center and describes a new method to slove the juction problem between abutting fields whose central axis are orthgonal.

MATERIALS AND METHODS

All 13 patients including 6 medullobalstoma, 5 germinoma, 1 CNS lymphoma and 1 endodermal sinus tumor were treated for WCSI at Asan Medical Center between Sptember 1989 and March 1991. All the patients were positioned prone in the custom-made half shell body cast during simulation procedure and daily treatment. They were treated on 4MV-6MV linear accelerator. There was a three level of moving juction and each juction was moved 1.5 cm distance superiorly or inferiorly at 900-1080 cGy increments (Fig. 1). The brain and cervical spine to C5-C7 was treated with bilateral fields at 100 cm SAD and the spine to S2 was treated with one or two direct posterior fields at 100 cm SSD, depending upon the size of the patients. If the spine was treated with two fields, appropriate skin gap was left so that the 50% isodose lines match at the mid-depth of the cord.

Author developed the following technique and treatment procedure for WCSI to ensure dose homogeneity at orthgonal three-beam junction.

1. The patient was positioned prone in the cast and leveled at the both tragus with the side laser lights and sagittal laser light.

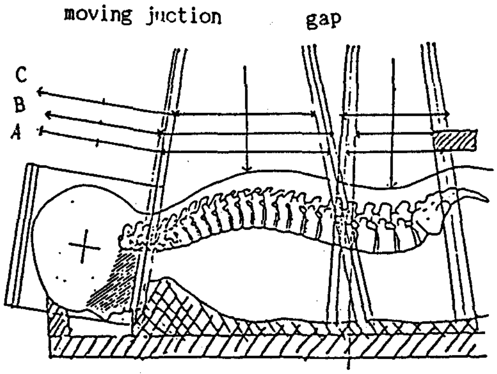
2. The spine field was set-up at first and the angle of light beam divergence was calculated by trigonometric function,

$\theta = \tan^{-1}$ (field size/2/SSD)

field size=Y-axis of spinal field.

If the spine is treated with two fields, the superior one was set-up first and angle θ was calculated by the above formula.

3. Second step was to set-up the lateral fields and for lateral field set-up, author utilized two differnt methods depending on the size of lateral



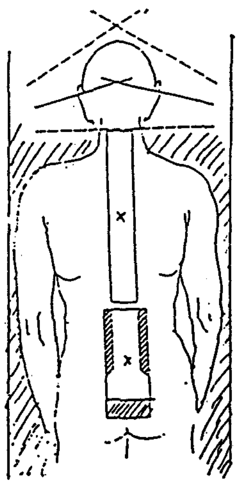


Fig. 1. Arrangement of treatment fields for WCSI; Junction moved 1.5 cm distance from A to B, C superiorly and inferiorly.

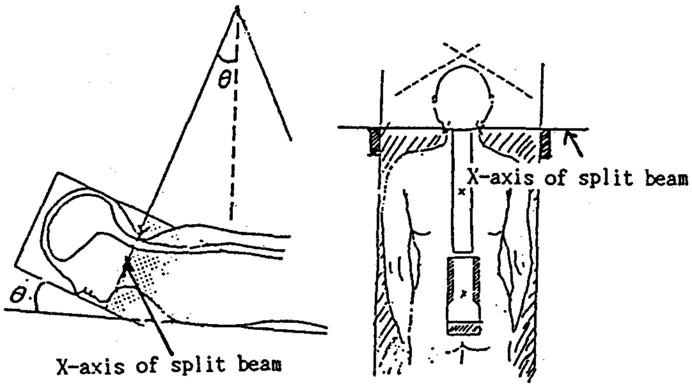


Fig. 2. Split beam technique (Method A); Split beam used for lateral field, rotated by angle θ to match the divergence of spine field.

field to include whole brain and cervical spinal cord upto the level of C5-7, avoiding shoulder.

If Y-axis of lateral field was less than 20 cm, split beam technique (method A) was applied. X-axis of split beam of lateral field was abutted upon the light edge of the spine field and axis of lateral beam was rotated by anlge θ by rotating the collimatior. The three-beam junction by two lateral fields and posterior field matched precisely by the edge of light beams (Fig. 2).

If Y-axis of lateral field was 20 cm or larger than 20 cm, couch rotation technique (method B) was applied.

The axis of lateral beam was roated by angle θ by rotating the collimator and the edge of light beam of lateral field was abutted upon the edge of light beam of posterior field on the skin of the sagittal plane. And the angle of divergence of beam for lateral field was calcuated by angle

$\alpha = \tan^{-1}$ (field size/2/SAD)

field size=Y-axis of lateral field.

Then couch was rotated by α angle so that edge of the lateral light beams matched precisely on the edge of diverged light beam of posterior field (Fig. 3).

4. The lateral bony canthus was marked with radiopaque material on the both eyes and lens, facial structure and anterior of neck were protected by 10 cm alloy block from entering and exiting beams.

RESULT

Radiation dose at the edge light beam was calibrated at 50% of isodose line and periodic measurements with water-phantom system

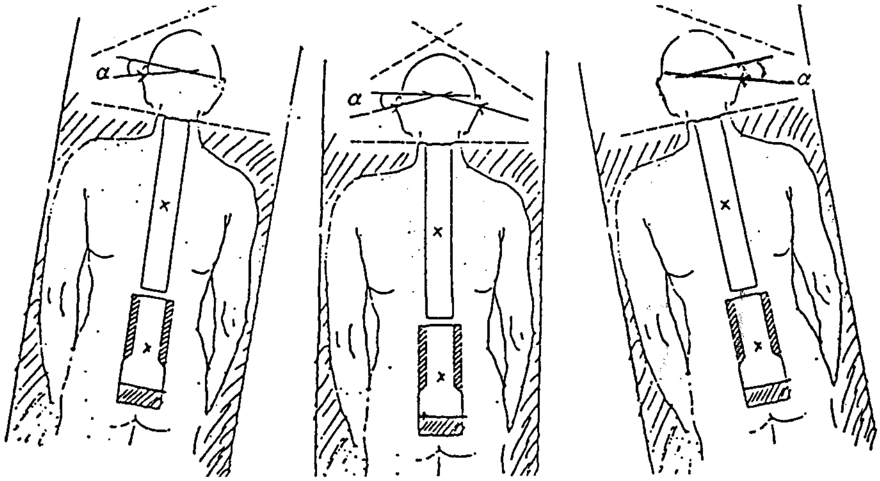


Fig. 3. Couch rotation technique (Method B); Axis of lateral field rotated the collimator angle θ and couch angle α to match the divergence of lateral beam and spinal posterior beam precisely at the light beam edge.

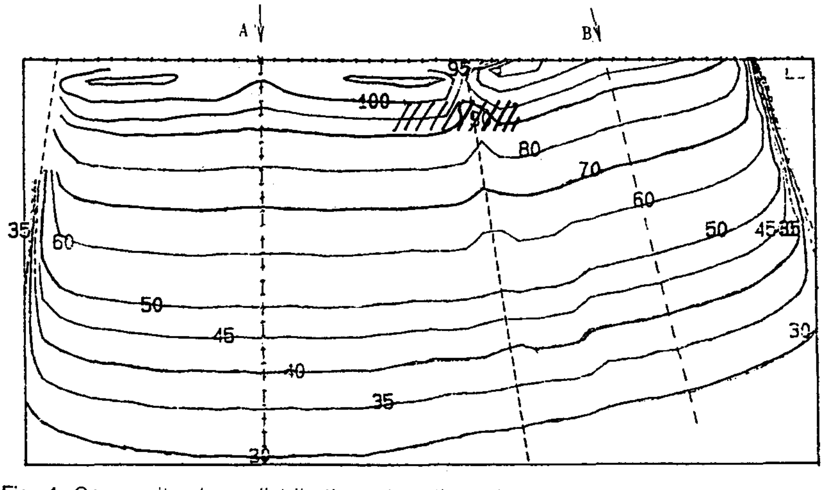


Fig. 4. Composite dose distribution when the axis of beams rotate to match the diverged edge of beams, on 4MV, field size 30 cm long, 20 cm long. Shade area shows the junction area at the depth 3~5 cm. Computed by Theraplan.

(Multidata, U.S.A.) and film dosimetry ensured that the 50% of isodose line of the photon beam coincided with the geometric edge of the beam and edge of the light beam. The accuracy of the Theraplan at the edge of the large field was confirmed by measurement up to 30% isodose line and 50% line coincided precisely with the gemoetric edge of the beam.

Fig. 4 and 5 show the composite dose distribution at the juction when the axis of beams rotate to match the diverged edge of beams on 4MV and 6MV, respectively. Figure 6 and 7 show the compopsite dose distribution at the junction when axis of split beam rotates to match the divergence of abutting field on 4MV and 6MV, respectively.

In all 13 patients, the depth of cord at three-beam junction varied 3 cm~5 cm depending on the size and contour of patient which was measured by CT scan and/or simulator film.

The variation in dose at the depth of 3 cm~5 cm is within 5% at the junction of Fig. 4~7.

So far author did not observe any marginal

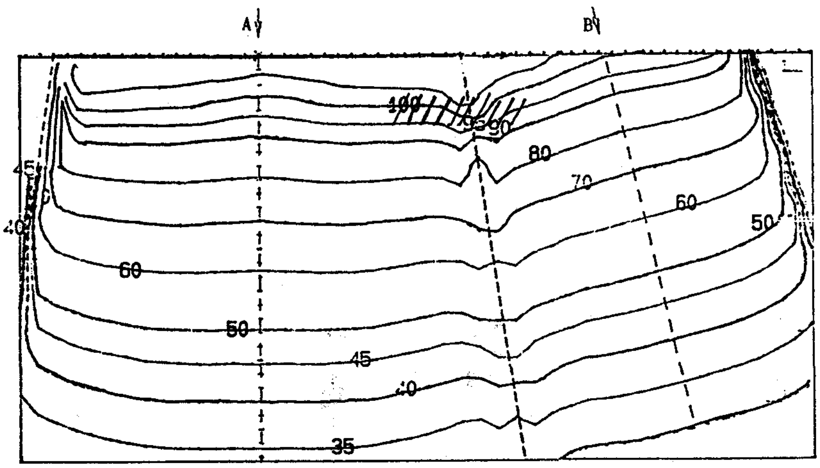


Fig. 5. Composite dose distribution when the axis of beams rotate to match the diverged edge of beams, on 6MV.

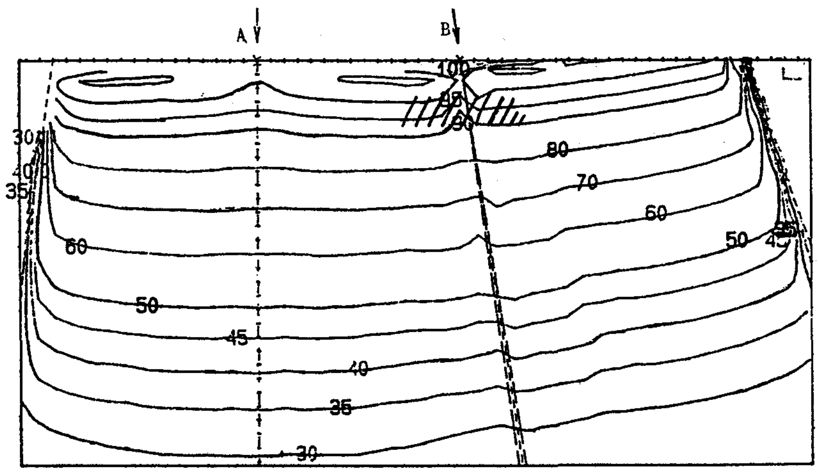


Fig. 6. Composite dose distribution when the axis of split beam was rotated to match the diverged edge of the field A on 4MV.

recurrence of untoward late complication and all patients of medulloblastoma, germinoma and CNS lymphoma are alive without disease with excellent performance status.

DISCUSSION

Several techniques for WCSI were explored to improve the accuracy and homogeneity of dose distribution at the juction of orthogonal beams[5~8]. Most authors report dose variation upto 60~70% at various depth of the three-beam junction and most of them utilized skin gap or beam spoiler at the homogeneity of dose distribution. If the three-beam juction was matched at the skin on sagittal plane without couch rotation, the variation of isodose distribution at 5 cm depth ranged 15% to 20%[7]. Clinical significance from isodose inhomogeneity ranged 15% to 20% can be further minimized by moving the match junctions and the risk for spinal cord damage is very low.

The technique and treatment procedure or WCSI at Asan Medical Center offers significant advantage for homogenous dose distribution at the three-beam junction (range of 5%) and avoids any hot or cold spots that may arise from beam diver-

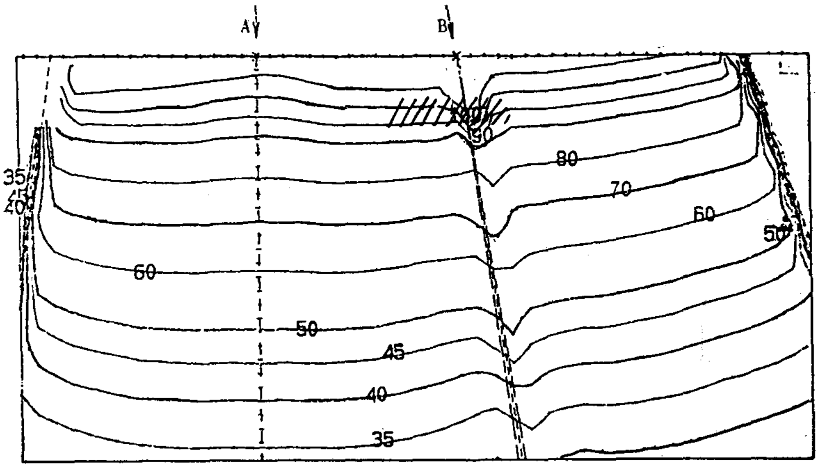


Fig. 7. Composite dose distribution when the axis of split beam was rotated to match the diverged edge of the field A on 6MV.

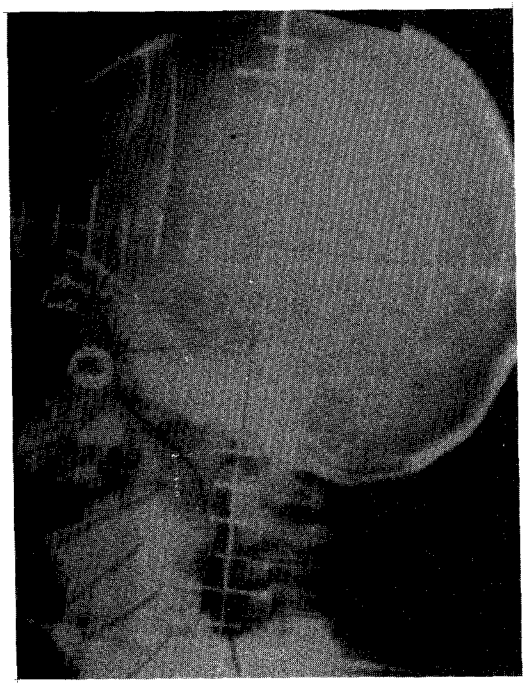


Fig. 8. Simulation film for the lateral field, showing tight margin at the retroorbital and cribriform plate.

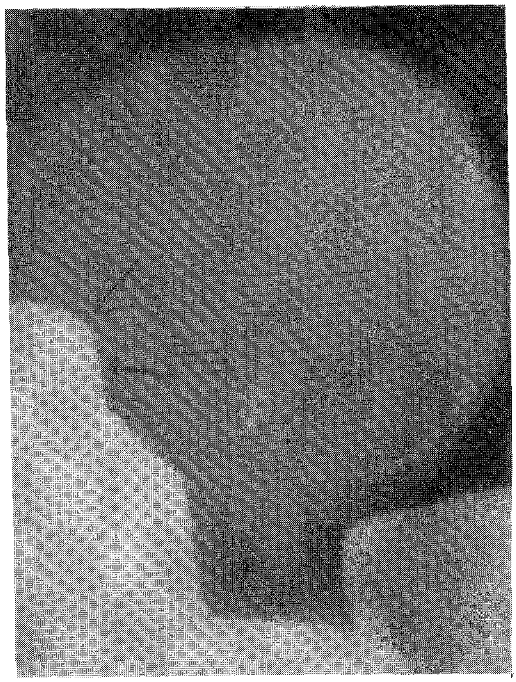


Fig. 9. Port film for the lateral field; arrow points the problem area

gence.

But the disadvantages of author's technique are as follows;

1. Skull anatomy of oblique plane is difficult to interpret.
2. Exit beam problem for contralateral eye worsens due to rotation of couch.
3. Facial block of brain field used to avoid exit beam to contralateral lens, may have blocked the retroorbital structure and cribriform plate.
4. Entire set-up for daily treatment is technically demanding.

The follow-up has been too short and number of patients are too small to assess the value of this demanding, elaborate technique, however author hopes that this technique may impove the outcome of medulloblastoma and germinoma.

REFERENCES

1. **Lance JS, Morgan JE:** Dose Distribution between adjoining therapy fields. Radiology 79:24-29, 1962
2. **Glenn DW, Faw FL, Kagan AR:** Field Separation in Multiple Portal Radiation Therapy. Am J Roentgenol 102:199-206, 1968
3. **Agarwal SK, Marks RD Jr, Constable WC:** Adjacent Field Separation for Homogenous Dosage at a Given Depth: Data for the 8MV Linear Accelarator. Am J Roentgenol 114:623-630, 1972
4. **Griffin TW, Schumacher D, Berry HC:** A Technique for Cranio-Spine Irradiation. British J Rad 49:887-888, 1976
5. **Dyk JV, Jenkin RDT, Leung PMK, Cunningham JR:** Medullobastoma; Treatment Technique and Radiation Dosimetry. Int J Rad Onc Biol Phys 2:993-1005, 1977
6. **Burkovitz AG, Deutsch M, Slayton R:** Orthogonal Fields: Variations in Dose vs. Gap Size for Treatment of the Central Nervous System. Radiolgy 126:795-798, 1978
7. **Vjayakumar S, Muller-Runkel R:** Medullobastoma Therapy Using Electron Beams. Radiology 157:541-542, 1985
8. **Lees RE, Kagan AR, Wollin M, Chan SL, Bellotti JE:** Pediatric Medulloblastoma: A new treatment technique. Med Dosimetry 13:143-147, 1988

= 국문초록 =

새로운 전중추신경 방사선 조사법 ; 방사선속의 발산에 의한 선량의 불균일성을 극복하기 위한 치료 방법

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장 혜 숙

전중추신경 방사선 조사는 수아세포종, 중추신경정상피종, 중추신경임파종, 중추신경백혈병 환자 치료에 시행한다. 뇌부위에는 양면 조사야를 통하고 척추 신경부위는 후면 단일 조사야를 통해 방사선 조사한다. 이때 조사야가 인접한 부위에서 발생하는 방사선조사야의 중첩에 의한 선량의 불균일성은 큰 문제로, 특히 척추신경의 극히 한정된 방사선 인내능력으로 인해 심각한 부작용을 병발할 수 있다. 이 문제를 해결하기위한 많은 연구가 보고되고 있으나 그들이 보고한 방법에 의해서도 불균일성은 최고 60%~70%로 부터 최소 15%~20%에 이른다. 저자는 split beam (central axis beam)과 collimator rotation technique을 이용하거나 collimator/couch rotation technique을 이용하여 3 조사야가 접하는 부위의 방사선량의 불균일성을 해결하고자 시도하였다. 저자의 방법으로 시행할때 3조사야가 접하는 부위에서의 불균일성은 5% 정도로 감소시킬 수 있었다. 본 논문에서 저자의 방법의 장 단점을 기술하였다.