Linac Based Radiosurgery (X-knife) for Brain Metastases

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Abstract

Linac based stereotactic radiosurgery by X-knife, technique that permits the precise delivery of a high dose of radiation from 6 MV linear accelerator to intracranial target(s) while sparing the normal tissue, has been used as an alternative treatment for brain metastasis. Five patients with 9 metastatic lesions were treated with this technique. The radiation dose was 15-25 Gy with the 75-80 per cent isodose line encompassing the enhancing tumor according to the tumor volume, site and previous treatment. All metastatic lesions were evaluated at 4 weeks after treatment, there were 2 CR, 4 PR and 3 remained unchanged. The result showed a very distinct clear radiation effect margin between the target and normal tissue. The patient could tolerate the treatment procedure well without any complications inherent to the technique. All patients with neurological symptoms had a satisfactory recuperation. Radiosurgery with X-knife is an effective and safe therapy for brain metastases. It can be applied as a primary treatment, as a booster in combination with whole brain irradiation, or as treatment for patients with relapse in a previous irradiated area.

Brain metastasis is one of the most common causes of death in malignancy. Radiation and chemotherapy have been used to increase survival, but failed to demonstrate a good result[1-5]. Surgical resection and whole brain irradiation was reported to give significant improvement in patients with solitary metastasis. However, surgery is perceived as an aggressive method and some brain lesions may be multiple or located in less surgically accessible areas. The well circumscribed and more or less spherical shape of metastatic lesions make them principally treatable with radiosurgical techniques. Several reports have shown a promising result with various types of machine[6-10].

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This report describes our experience with the linac based radiosurgery for metastatic brain lesions in terms of efficacy and accuracy of linear accelerator facility. (X-knife)

MATERIAL AND METHOD

From September to December 1995, 5 patients diagnosed with brain metastases from various malignancies with 9 metastatic lesions were treated by stereotactic radiosurgery at the Srisiam Hospital. The patients' characteristics are shown in Table 1.

Table 1. Patients' characteristics.

No.	Sex	Age	Primary	No. of lesions
1	M	72	lung	3
2	M	72	lung	1
3	F	66	breast	1
4	M	67	lung	1
5	F	67	melanoma	3

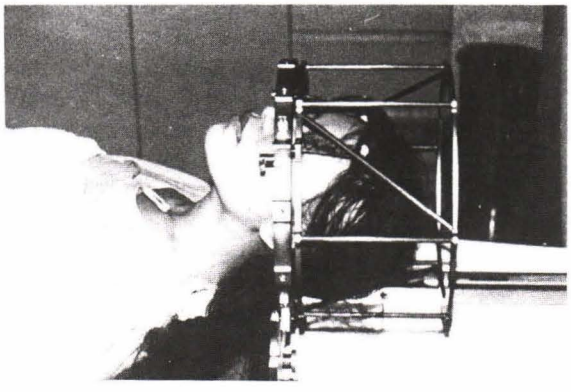

Fig. 1. The patient with BRW headring and localizing frame during CT scanning.

Radiosurgical technique

Radiosurgery is a four-step procedure including

1. Application of the stereotaxis headframe : The Brown-Roberts-Wells (BRW) Radionics headframe was attached to the patient's head with local anaesthesia by the neurosurgeon. The headring should be placed transverse to the patient's head and at least 1 cm below the lesion to avoid discomfort and treatment set-up problems (Fig. 1).

2. Stereotactic image : Computerized axial tomographic scan for tumor localization was performed with the headframe to derive the spatial coordinates of the intracranial target.

3. Treatment planning : After stereotactic CT investigation, the CT data were stored in a magnetic tape and transfered to the computerized planning system for X-knife treatment planning program. The CT images were used for outlining the external surface, the tumor and surrrounding critical structures such as brain stem, eyes, optic nerves and optic chiasma. The external volume and three dimensional structures were shown in the computer and ready for the treatment planning. The isocenter with suitable collimator was defined in the tumor and the multiple non-coplanar radiation beams were planned from various directions. The dose was prescribed to be 15-20 Gy at 70-89 per cent isodose line. If the tumor had an irregular shape, multiple isocenters were used.

4. Radiation treatment with a good quality assurance : Before starting the radiation treatment, we have to ensure that the radiation field conforms precisely to the surgical target. Dose distribution is facilitated by 3-D visualization. The dose volume histograms of the primary lesion and the surrounding critical structures and other analytical tools were also used for final decision of the treatment planning. Once the desired treatment protocol has been accepted, the treatment set up is proceeded by at least 2 radiotherapists under the supervision of the radiation oncologist.

RESULTS

The number of lesions, number of isocenters, prescribed doses, results of treatment and complications are shown in Table 2.

All of the patients were evaluated at 4 weeks with CT scan. Two lesions out of nine showed complete response (CR) and 4 showed partial response (PR). Only the case of malignant melanoma with 3 metastatic lesions showed no response to the treatment and developed acute complications such as nausea, vomitting and stuperous consciousness. However, the complications can be controlled by steroid therapy.

The efficacy and accuracy of the treatment procedure can be shown by the follow-up CT

Table 2. The number of lesions, number of isocenters, prescribed dose, results of treatment and complications.

No.	Lesion (s)	Isocenter	Dose	Result	Complication
1	3	3	15	2 CR 1 PR	nil
2	1	3	20	PR	nil
3	1	2	20	PR	nil
4	1	1	15	PR	nil
5	3	4	15	SD	brain edema

Note : CR = Complete response
PR = Partial response
SD = Stable disease

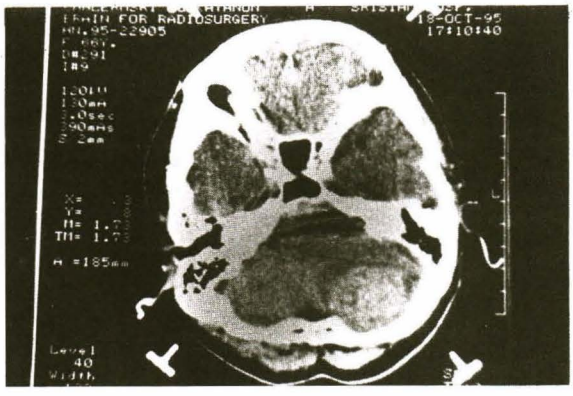

Fig. 2. CT scan shows a lesion in the right cerebellum, metastasis from breast cancer.

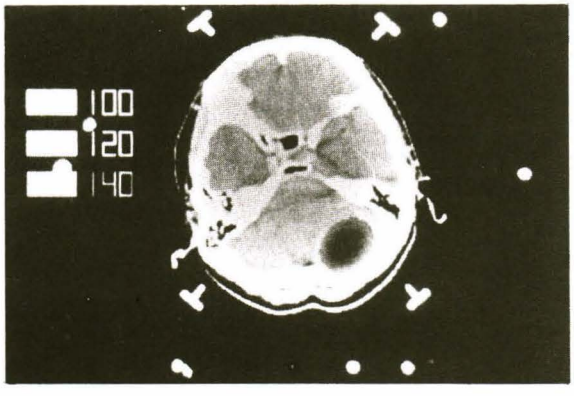

Fig. 3. CT scan with the dose distribution.

scan of the patients that some lesions disappeared and some became smaller in size with the central necrosis. There was no reaction in the adjacent area, as shown in Fig. 2-4.

Fig. 4. CT scan 1 month later shows central necrosis and decrease in size of the tumor with no reaction in the adjacent area.

DISCUSSION

The aim of treatment of patients with brain metastasis is generally palliation. The established treatment modality for cerebral metastasis has been craniotomy for a single lesion and whole brain radiation therapy for one or more lesions. The main objective of radiosurgery is local control with optimized neurological function. The neurosurgical complication can also be omitted with this process. The convenience and efficacy of radiosurgery procedure has led to an increasing use of this treatment procedure for both single and multiple metastasis (3 or fewer)[11-13,16,18]. Excellent results have been achieved with this technique, even for such traditionally radioresistant tumors as melanoma[11-13,17,20].

During our starting period, we treated the patients with 3 or fewer lesions. The procedure is convenient for the patients, and it can reduce the whole period of palliative treatment. The result was fair and there was no complication. Only in case No 5, we treated 3 out of 7 lesions of metastatic melanoma. This might be the reason why she developed the immediate complication of increased intracranial pressure.

However, from the treatment planning and follow-up CT scan, we can conclude that radiosurgery with X-knife is a very simple and convenient treatment procedure. The efficacy and accurary are well accepted. It can also minimize the long duration of palliative treatment.

Even the result is promising but a longer follow-up period and larger number of patients should be treated in order to conclude the definite

role of radiosurgery in brain metastases. Various controversial aspects such as stereotactic radiosurgery *vs* stereotactic fractionation radiotherapy or radiosurgery alone *vs* radiosurgery combined whole brain irradiation should be further investigated[11,12,14,20].

SUMMARY

Linac based radiosurgery with X-knife is a safe and effective procedure for the treatment of brain metastasis. Further investigation for the specific indication of treatment and combination with other madalities should be done.

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การรักษามะเร็งแพร่กระจายมาที่สมองโดยการฉายรังสีสามมิติ

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การผ่าตัดด้วยรังสีโดยการฉายรังสีสามมิติ เป็นเทคนิคการรักษารอยโรคในสมองด้วยรังสีเอกซ์ พลังงาน 6 MV ที่สามารถให้รังสีปริมาณสูงจำกัดอยู่ในตำแหน่งเฉพาะที่ ในขณะที่เนื้อสมองปกติโดยรอบได้รับปริมาณรังสีต่ำมาก ซึ่งได้นำมาใช้ในการรักษามะเร็งที่แพร่กระจายมายังสมองด้วยในรายงานนี้ ได้ให้การรักษาด้วยมีดรังสีเอกซ์ในผู้ป่วยมะเร็งที่มีการแพร่กระจายของโรคมายังสมองรวม 9 ตำแหน่ง ในผู้ป่วย 5 ราย ปริมาณรังสีที่ใช้อยู่ระหว่าง 15–20 Gy ที่เส้น isodose ที่ 75–80% ขึ้นอยู่กับขนาดและตำแหน่งของรอยโรค, ชนิดของมะเร็ง และการรักษาที่เคยได้รับ หลังการรักษา 4 สัปดาห์ ได้ให้การตรวจเอกซเรย์คอมพิวเตอร์ของสมอง พบว่ารอยโรคยุบหายไปหมด 2 ตำแหน่ง รอยโรคยุบลงมากกว่า 50% 4 ตำแหน่ง และรอยโรคยังคงขนาดเดิม 3 ตำแหน่ง ไม่พบความผิดปกติในเนื้อสมองปกติโดยรอบ ผู้ป่วยไม่แสดงอาการผิดปกติหรือเกิดมีภาวะแทรกซ้อนที่เกี่ยวเนื่องกับการรักษา อาการผิดปกติทางระบบประสาทที่มีอยู่ก่อนการรักษาหายไป การผ่าตัดด้วยรังสีโดยเครื่องเร่งอนุภาคนี้ เป็นการรักษาที่ดีและปลอดภัยในมะเร็งที่แพร่กระจายมายังสมอง สามารถใช้เป็นการรักษาหลักหรือการฉายเพิ่มเติมจากการฉายรังสีอาบสมอง รวมทั้งใช้ในตำแหน่งที่เคยได้รับการฉายรังสีมาแล้วด้วย

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