

An old approach made new in the radiation treatment of brain tumours - The Ottawa experience

By Dawn Stacey and Deborah Gravelle

Abstract

Stereotactic radiosurgery and fractionated stereotactic radiotherapy are new technological advances in the delivery of radiation therapy to brain lesions. These advances give new hope for some patients. The nurse in radiation oncology plays an essential role in explaining the complex treatment process to the patient and monitoring patients for side effects of treatment. This article discusses the roles of stereotactic radiosurgery and fractionated stereotactic radiotherapy, treatment planning and delivery, side effects, and nursing implications.

Stereotactic radiosurgery (RS) is a technique that permits very precise delivery of a single large fraction of radiation to small areas of the brain. By concentrating the dose exactly where it is needed with a rapid fall-off of radiation outside the target area, the surrounding normal brain tissues can be spared unnecessary radiation. RS makes it possible to treat with higher than usual radiation doses without any increase in side effects. Fractionated stereotactic radiotherapy (SRT) uses the technical and treatment planning principles of RS to deliver multiple fractions (similar to regular external radiation therapy) to small areas of the brain. Both treatments require highly sophisticated treatment planning, high-energy radiation machines and specialized immobilization devices.

History

RS, as an alternative to brain surgery, has been in use for over 40 years (Verhey, 1995). The characteristics of surgery and RS/SRT for brain tumours are displayed in Table One. Originally, RS was used for the treatment of pain, movement disorders and psychiatric illnesses. Later, its use was extended to treat arteriovenous (AV) malformations and benign brain tumours. Malignant tumours were not initially considered for RS because of their larger size and tendency to spread. It is only in the last decade that this highly sophisticated technique has been reconsidered and implemented in the treatment of both primary and metastatic malignant brain tumours. Presently RS and SRT are available only at select cancer treatment centres.

For many years, single fraction RS has yielded good results for non-cancerous tumours and AV malformations. The same technique used for malignant brain tumours is believed to be able to increase survival and improve quality of life but still needs to be proven in clinical trials.

RS requires a specialized immobilization device. Most cancer centres use a metal frame that is surgically fixed into the patient's skull by screws. In Ottawa, a team of physicists, radiation oncologists and a dental surgeon has developed an accurate method to immobilize the patient that is less invasive and does not require hospitalization or surgery. The immobilization device is based on an individually made cobalt-chrome "bite-plate" that securely fits onto the upper teeth. The "bite-plate" then attaches to a stereotactic frame. With the "bite-plate" in place on the upper teeth and attached to the frame, the patient is unable to move during treatment. With the application of this stereotactic frame, it is now possible to deliver multiple

daily fractions (fractionated treatment) with a safe, reproducible system while maintaining patient comfort. In Ottawa, both RS and SRT are available (Szanto, 1994).

The potential advantage of fractionated treatment over single fraction is a reduction in late radiation side effects on normal brain tissue. A secondary potential advantage of fractionation is that re-oxygenation of brain tissue can occur between fractions increasing the overall effectiveness of treatment. Many brain tumours contain hypoxic cells that are resistant to radiation. In a fractionated course of treatment, each dose primarily kills aerobic cells. The timing between fractions allows hypoxic cells to re-oxygenate (Hall, 1993).

Indications

Tumours that are ideal for RS and SRT are spherical, relatively small (<30mm), distinct from normal brain tissue, and entirely within the treatment area (Loeffler, 1995). RS and SRT are indicated for treatment of AV malformations, benign tumours (i.e. meningioma, acoustic neuroma, pituitary adenomas), malignant primary tumours (i.e. gliomas) and metastatic tumours.

Goal of treatment

The goal of treatment depends on the type of brain lesion being treated. For the treatment of AV malformations, the goal is thrombosis and occlusion of the AV malformation (Shaw, 1995). For benign and malignant tumours, the primary goal is reproductive cell death or antiproliferative effect.

Treatment planning

To prepare for treatment using the "bite-plate" immobilization device, the patient goes through the following procedure:

Step 1: A specialized cobalt-chrome "bite-plate" prosthesis is made (see Figure One). The prosthesis is molded individually for each patient and securely fits onto the upper teeth; the prosthesis is then attached to the stereotactic frame (see Figure Two). Patients state that the device is comfortable. While in place, patients can move their lower jaws, swallow, and speak quite freely. The accuracy of the immobilization device has been demonstrated clinically with repeat treatments being given to within 0.6 millimeters of precision (Szanto, 1995).

Step 2: A treatment planning CT scan is done with the "bite-plate" prosthesis attached to the stereotactic frame. Patients who require treatment for AV malformations have an angiogram as well as a CAT scan performed to achieve precise localization of the lesion.

Step 3: Using the information from the CT scan, the physicist, radiation oncologist, neurosurgeon, radiologist and dosimetrist plan the treatment on a computer.

Step 4: The CT scan is repeated to confirm the geometrical accuracy of the treatment plan.



Figure One: Bite-plate prosthesis.

Dawn Stacey, RN, BScN, OCN, is clinical teacher - nursing, and Deborah Gravelle, RN, BScN, OCN, is charge nurse at the Ottawa Regional Cancer Centre, Ottawa, Ontario.

The treatment procedure

Treatments are delivered by a linear accelerator radiation machine and use high energy x-rays. The patient is usually positioned supine with a wedge under his/her knees and hands across his/her abdomen. The head is placed in the stereotactic frame with the "bite-plate" in his/her mouth (see Figure Three).

The treatment involves a series of arcs of radiation delivered precisely to the target area in the brain (see Figure Four). The treatment bed is rotated between arcs to establish the plane for the next arc. RS is



Figure Two: Patient with bite-plate prosthesis in place.



Figure Three: Patient positioned in the stereotactic frame.

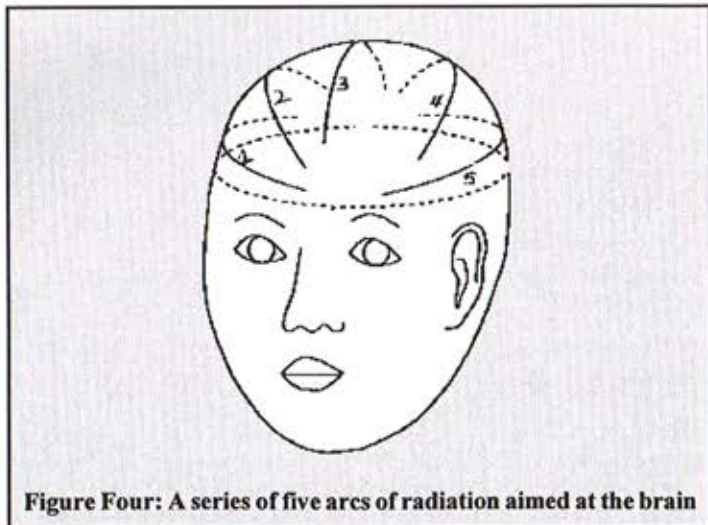


Figure Four: A series of five arcs of radiation aimed at the brain

given in one treatment while SRT is given over five to 25 treatments. The number of fractions depends on the type of brain lesion, previous radiation therapy and goal of treatment.

The initial time on the treatment machine is scheduled for approximately 90 minutes. The actual treatment time for RS is usually 15 minutes, depending on the dose, and only a few minutes for SRT. Subsequent treatments, if necessary, are usually scheduled for 30 minutes. Most of the scheduled time is required for the quality assurance checks of the linear accelerator and for setting up and verifying the accuracy of the intended treatment.

Over the last two years, 20 patients have been treated at the Ottawa Regional Cancer Centre with RS and SRT using the "bite-plate" immobilization device. Treatment results have shown good control of brain metastasis and excellent control of AV-malformations. Treatment of primary brain tumours is occurring in clinical trials with no interim review done to date. Table Two describes patients treated.

Side effects

The side effects experienced by patients receiving RS or SRT depend on a variety of factors. Factors include prior or concomitant therapy (i.e. external radiation therapy, chemotherapy and surgery), the patient's general health, patient's age, location and size of the brain lesion, and dose factors. In RS cases, the total dose is important and for SRT, the total dose and fraction size are important. Side effects occur when normal brain cells in the field of treatment are destroyed. The destruction of normal cells produces an inflammatory effect which results in cerebral edema.

Acute side effects

(occurring within three months)

Only a small percentage of patients receiving RS or SRT experience cerebral edema. Of these patients, the following are the side effects they may experience as a result of the cerebral edema.

Headaches: Headaches are the most common complaint caused by cerebral edema, and are managed with a combination of corticosteroids and acetaminophen.

Seizures: Seizures are more likely to occur in patients with pre-existing seizure disorders. Appropriate anticonvulsant medications are usually prescribed.

Changes in pre-existing neurological deficits: As a result of cerebral edema, patients may experience personality changes, irritability, visual deficits, short-term memory loss, hemiplegia, sensory deficits, or speech/language dysfunction. Subtle initial changes are usually noticed by family members. Patients should be assessed regularly by a nurse or physician for any changes.

Nausea and vomiting: Nausea and vomiting are less common. These symptoms are more likely to occur if the treatment area is close to the nausea centre in the brain stem. If nausea occurs, the patient is prescribed an anti-emetic.

Table One: Characteristics of surgery and RS/SRT for brain tumours

Surgery to brain

- Quickly resolves the effects of the brain tumour
- Some tumours are inoperable due to location
- Hospitalization required
- Provides diagnostic information
- Serious side effects: risk of haemorrhage, stroke, infection, tumour seeding, neurological impairment

RS and SRT to brain

- Improved treatment to tumour margins
- Treatment for inoperable brain tumours or poor risk surgery patients
- May be used in patients previously treated with radiation to the brain
- Minimal or no hospitalization
- Biopsy generally required to confirm diagnosis
- Serious side effects: seizures, acute cerebral edema, radiation necrosis

Alopecia and scalp irritation: Patients receiving only RS or SRT to superficial brain lesions will experience transient alopecia; with the treatment of deep-seated brain lesions, the scalp dose is too low to cause alopecia.

Chronic effects

(occurring beyond three months)

Radiation necrosis: Radiation necrosis (RN) occurs in a small percentage of patients and is characterized by development of new or worsened neurological symptoms occurring six months to three years post-radiation. RN is thought to occur as a result of damage to normal brain tissues such as blood vessels and brain parenchyma. Radiological tests usually demonstrate cerebral edema and most patients improve on corticosteroid medications. Surgical resection of the necrotic area is occasionally required for treatment of radiation necrosis (Shaw, 1995).

Treatment with SRT potentially reduces the risk of necrosis compared to RS because of preferential sparing of the brain tissue and blood vessels.

Nursing care issues


Prior to commencing RS or SRT treatment, it is important for the nurse to assess the patient's and family members' knowledge of the treatment and provide teaching accordingly. There are very limited educational resources about this treatment available to patients. To assist patients' understanding of the treatment, a patient teaching tool specific to the treatment technique used in Ottawa was developed.

Patients receiving radiation to the brain, whether whole brain radiation or RS and SRT, require a baseline neurological assessment with regular reassessment. The neurological assessment should focus on symptoms experienced at the time of diagnosis. It is these symptoms, such as headaches, seizures and neurocognitive dysfunction, which may recur or worsen as a result of cerebral edema during treatment. The most common intervention used to decrease cerebral edema is the administration of corticosteroids as prescribed by the physician. Patients should be instructed to report signs of gastric irritation and other side effects of the medication (i.e. increased appetite, fluid retention and irritability). Instruction is offered to patients about increased risk of infection and the need to avoid obvious sources of infection. Patients are taught the importance of following dose tapering regimens when discontinuing corticosteroids to avoid adrenal insufficiency. Teaching patients about the use of acetaminophen to manage headaches and anticonvulsants as prescribed for seizure control are equally important. Patient safety is included when providing teaching relevant to managing neurological symptoms.

At the end of treatment, the primary concern for the patient is the signs and symptoms of recurrent disease. The nurse needs to clearly inform the patient to report a worsening of neurological symptoms. Frequently, patients will experience symptoms similar to those experienced when the patient was initially diagnosed.

Throughout the cancer experience, the nurse plays a key role in referral to support services and community resources. One of the most accessible resources for adults and children with brain tumours and their families is the Brain Tumour Foundation of Canada. It offers local support groups, informational materials and a telephone hotline (1-800-265-5106).

Conclusions

Currently, Ottawa has the only Canadian cancer centre where a non-invasive relocatable immobilization device is available for RS and SRT. This new method of giving radiation therapy is one of the most advanced systems of RS and SRT currently available and offers new hope for some patients with brain lesions. Recent developments in treatment planning, non-invasive immobilization devices and delivery of RS and SRT for brain lesions may form the basis for the approach being used to treat other areas of the body. Nurses working with oncology patients must keep abreast of such new developments in radiation oncology treatment. 

Acknowledgements

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References

- Hall, E., Brenner, D. (1993). The radiobiology of radiosurgery; rationale for different treatment regimens for AVMs and malignancies. *International Journal of Radiation, Oncology, Biology, Physics*, 25, 381-385.
- Loeffler, J.S., Shrieve, D., Wen, P., Fine, H., Kooy, H., Addesa, A., Black, P., Alexander, E. (1995, July). Radiosurgery for Intracranial Malignancies. *Seminars in Radiation Oncology*, 5(3), 225-234.
- Szanto, J., Gerig, L.H., Malone, S., Girard, A., Ragnitz, H., El-Hakim, S. (1995). Improved Immobilization and Verification of Fractionated Stereotactic Radiotherapy. *Radiotherapy & Oncology*, 37(Suppl. 1), 536.
- Szanto, J., Gerig, L.H., Girard, A., Ragnitz, H. (1994). The Ottawa System for Fractionated Stereotactic Radiotherapy. *AAPM*, 21(6), 890.
- Shaw, E.G., Coffey, R.J., Dinapoli, R.P. (1995, July). Neurotoxicity of Radiosurgery. *Seminars in Radiation Oncology*, 5(3), 235-245.
- Verhey, L.J., Smith, V. (1995, July). The Physics of Radiosurgery. *Seminars in Radiation Oncology*, 5(3), 175-191.

Table Two: Types of brain lesions treated with RS/SRT

| Uses of RS/SRT | Type of pathology | Previous treatment | RS/SRT total dose (cGy) | # fractions |
|------------------------------|---|--|-------------------------|-------------|
| Definitive treatment | AV malformation | Inoperable due to depth within the brain and high risk of neurological deficits | 2000 | 1 |
| Treatment of residual tumour | Glioblastoma | 5940 cGy external radiation | 2000 | 10 |
| Treatment of residual tumour | Meningioma | Inoperable due to location; 4000 cGy external radiation | 2000 | 10 |
| Recurrent tumour | Astrocytoma | Craniotomy for total resection and external radiation; Recurrence 1 year later - surgery with subtotal excision. | 3500 | 7 |
| Palliative treatment | Melanoma with solitary brain metastasis | 3000 cGy external radiation | 1500 | 1 |