LEADING ARTICLE

CT-DIRECTED STEREOTACTIC NEUROSURGERY

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Stereotactic neurosurgical techniques allow the insertion of instruments accurately into targets within the brain with minimal injury to the overlying or adjacent brain. This technique was first used clinically in the 1950s and 1960s for the treatment of involuntary movement disorders. After a relatively brief period of popularity, interest in stereotactic surgery waned after the introduction of L-dopa in 1968[1].

When CT scanning was introduced in the mid-1970s, a "marriage" with stereotactic techniques was inevitable. Both techniques involve three-dimensional orientation of brain structures, both techniques are based on Cartesian coordinates, and both techniques involve localization of a target in the space within the head.

CT, MRI and even angiography have now been incorporated into stereotactic techniques. The rapid development of powerful computers with fast microprocessors and graphics capability has made it possible to plan out beforehand, based on the CT, MRI and angiography images, the relation of a probe path to critical structures in the brain. For example, by assessing, before actually carrying out the procedure, whether a probe path will hit a major vessel, a major complication may be avoided. A path can be selected preoperatively to avoid an important area of the brain.

The Leksell and the Mundinger-Riechert stereotactic systems of the early 1950s have been successfully adapted for use with the CT and MRI. In the last ten to fifteen years, several other new stereotactic systems have also been developed, designed specifically around CT scan parameters. The BRW CT-guided stereotactic system, first used in May 1988 at the Department of Neurosurgery, Tan Tock Seng Hospital, is one such system.

The paper in this issue reports the author's experience with the BRW system at Tan Tock Seng Hospital. The accuracy of the BRW system has been well documented by others[2,3]. Apuzzo and Sabshin pointed out that while the small quantities of tissue that are accessed by the technique are in part responsible for the high level of patient tolerance of the procedure, difficulty may be encountered by a pathology service that is not experienced in processing such material[3]. This must be taken into consideration when the surgeon chooses between stereotactic and open biopsy, especially in hospitals without the services of full-time neuropathologist.

Currently, the main use of CT or MRI guided stereotactic surgery is in the biopsy of deep lesions within the brain. Other uses currently being developed include interstitial brachytherapy, linear accelerator radiosurgery, aspiration of haematomas within the brain or brainstem, transplantation of neural grafts in the central nervous system, and stereotactic directed craniotomy.

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Interstitial brachytherapy involves the intratumoural placement of one or several radiation sources, usually ^{125}I or ^{192}Ir[4]. The advantage is that the radiation dose to the surrounding tissues decreases rapidly with increasing distance from the source, thus delivering the highest dose possible to the tumour and protecting the surrounding brain. Sophisticated computer programs have simplified pretreatment planning. Treatment catheters are then implanted using stereotactic techniques.

A development that will probably have an important impact on the future of neurosurgical practice is stereotactic directed craniotomy. By planning the trajectory of the probe to provide the safest approach to a deep intracranial lesion, the neurosurgeon can site the craniotomy accurately and approach the lesion even though it is not apparently on inspection or palpation of the cortical surface. When the lesion is reached, standard microneurosurgical techniques are then used for its extirpation. Special stereotactic frames, such as the CRW frame and the ZD frame, have been developed to facilitate microneurosurgery without the arc getting into the way of the surgeon or the microscope.

A further development, pioneered by Patrick Kelly, is computer-assisted stereotactic craniotomy[5]. In this technique, an operating room computer system and appropriate software for the transposition of volumetric information derived from CT scans and MRI images into three-dimensional space is used to monitor and display the position of stereotactically directed instruments in relation to computer generated reconstructions of the tumour volume. This advanced form of stereotactic craniotomy is gradually being implemented in leading neurosurgical centres.

Another rapidly developing area is in the use of the linear accelerator as a neurosurgical tool for stereotactic radiosurgery[6]. "Stereotactic radiosurgery" is the term first used by Leksell in 1951 to describe the technique he developed in which an X-ray beam was cross fired at a predetermined location within the head as the collimator moved along a track that circumscribed an arc over the head. Stereotactic radiosurgery uses radiation to obliterate tissue that is either inaccessible or unsuitable for open surgical approaches by inducing gliosis or fibrosis within it. The greatest experience has been with the treatment of small to medium size cerebral or brain stem arteriovenous malformations.

Stereotactic surgery has regained a mainstream position within neurosurgical practice. Its applications are still being explored and are expanding rapidly. A CT and MRI guided stereotactic system is now an essential equipment in any clinical neurosurgical department. The neurosurgeon, however, must exercise good clinical judgement in selecting patients for stereotactic surgery. He must be careful not to recommend the procedure merely to gain experience.

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