Summary

Diagnostic quality

Alignment of bones

Femur: tibia
Patella

Bone margins and density

Femur, tibia, patella, fibula

Cartilage and joints

Femorotibial
Patellar-femoral

Soft tissues

Effusions

Lipohaemarthrosis

Chondrocalcinosis

Surgical emphysema

Foreign bodies

An ununited accessory ossification centre of the fibular head will have a smooth corticated margin unlike a fracture. A thin line of ossification may also be seen in the medial collateral ligament next to the insertion point on the medial femoral epicondyle. This is caused by an old avulsion injury of this ligament with subsequent calcification within the subperiosteal haematoma (Pelligrini-Stieda disease) (fig 9).

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The line drawings were prepared by Mary Harrison, medical illustrator.

The ABC of Emergency Radiology has been edited by David Nicholson and Peter Driscoll.

Minimally Invasive Surgery

Neurosurgery

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This is the seventh in a series of articles describing the current techniques in minimal access surgery. The articles have been written to inform non-specialists of developments in this rapidly moving area.

The introduction of minimally invasive techniques has greatly improved results for intracranial neurosurgery. Stereotaxy and improved imaging techniques have reduced surgical trauma by allowing surgeons to plan the least damaging route to operative sites and by increasing surgical precision. Stereotaxy has also allowed brain biopsies to be taken from sites such as the brain stem, which were rarely sampled before because free hand biopsy was so dangerous. Brain tumours can now be treated by interstitial radiotherapy—stereotactic insertion of catheters into the lesion for loading of radioactive iodine—or radiosurgery—focusing of intense beams of radiation on lesions without needing surgical incisions. Endoscopic neurosurgery can be used to reach cavities such as the ventricular system or cystic tumours. With interventional neuroradiology fine catheters can be introduced into most vessels in the cranium for embolisation or dilatation. The development of augmentative functional neurosurgery means that movement disorders, epilepsy, and intractable pain can be treated with implanted neurostimulating electrodes. Future developments will probably include frameless stereotaxy, when the rigid attachment of stereotactic apparatus to the patient's head can be dispensed with, and at least partial automation of procedures such as brain biopsy.

During the last three decades the results of intracranial neurosurgery have improved, largely due to better neuroanaesthesia and the introduction of glucocorticoids to control cerebral oedema and the operating microscope. Most major intracranial neurosurgical procedures, however, have a high potential for morbidity and mortality because of the physical sensitivity and neurological eloquence of the structures involved. In minimally invasive neurosurgery surgical techniques, particularly stereotaxy, have been coupled with improvements in neuroradiological imaging to increase precision and to reduce trauma to normal tissues.

Stereotaxy

Stereotaxy was introduced by Horsley and Clarke at the beginning of this century for experimental brain

FIG 1—Stereotactic frame in use during craniotomy. Entry point and trajectory to target have been chosen

surgery in animals and has been successfully developed for clinical use in humans over the past 40 years.¹ Technically satisfactory systems are now commercially available, the most popular being the CRW (Radionics, Boston, USA) (fig 1) and Leksell (Elekta, Stockholm, Sweden). With such devices a probe can be introduced into a known part of the brain identified by imaging and a knowledge of brain anatomy. A computer can be used to generate a three dimensional image so that the surgeon can choose the least damaging route to the operative site.

The basic principle of nearly all current stereotactic equipment is firm fixation of the stereotactic apparatus to the patient's skull vault with metal pins or, more recently, dental fixation (fig 2). The second method is less invasive and allows the frame to be applied repeatedly so that stereotactic imaging, planning of treatment, and surgery may be carried out at different times. For stereotactic surgery local anaesthesia can be used, but general anaesthesia provides optimal control of intracranial conditions.

Stereotactic biopsy and craniotomy

In stereotactic brain biopsy a fine cannula just over 1 mm in diameter is passed down into the radiographic-

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Sites of lesions biopsied under computed tomographic guidance in 300 consecutive cases

Site	No of cases
Frontal, frontal-parietal, and fronto-temporal	68
Parietal	39
Temporal and temporo-parietal	47
Occipital	10
Internal capsule	4
Corpus callosum	10
Pituitary	7
Pineal	8
Third ventricle	7
Thalamus and basal ganglia	34
Brain stem*	37
Cerebellum	1
Multiple	28

*Including eight cases of stereotactic aspiration of brain stem haematomas revealed by computed tomography.

ally visible lesion to obtain a biopsy. The table shows the anatomical sites of lesions that were biopsied in a series of 300 consecutive patients in our unit over six years. The series included 37 brain stem lesions, which were rarely biopsied before stereotactic methods became available because free hand biopsy was too dangerous. The differential diagnosis in all cases included the possibility of malignant brain tumour requiring histological verification. Although the antici-

FIG 2—Patient fitted with repeat stereotactic localiser. Accurate fixation provided by unique detail impression of upper dentition

FIG 3—Series of axial slices of brain by computed tomography. Recurrent tumour outlined in white with proposed radiations superimposed

FIG 4—Three dimensional reconstruction of scans shown in fig 3. Tumour is blue, proposed radiation dose is red, and positions of catheters are green lines. Surrounding fiducial rods are used in stereotactic planning

pated diagnosis was confirmed in most of the cases, an unexpected diagnosis was made in 51 cases. In 30 of the cases the biopsy cannula was also used for therapeutic purposes, including aspiration of 15 haematomas and three brain abscesses.

The success of free hand biopsy of the brain varied from unit to unit and depended in particular on the part of the brain to be sampled. The best reported figures included mortality of up to 5% and 10% serious morbidity of 10%.^{2,3} The operative mortality in our series of 300 patients undergoing biopsy is now down to 0.3% (one patient) with a serious morbidity of just over 2%. More importantly, the success rate in terms of obtaining a definitive histological diagnosis has risen from less than 80% in series with free hand biopsy to 90–95% with stereotactic biopsy. The technique may be modified and a small craniotomy performed in order to resect small superficial tumours. Such stereotactically guided craniotomies allow the surgeon to make smaller scalp incisions and skull openings as well as providing accurate guidance to the tumour with a minimum of brain retraction and dissection. All these features help to decrease the morbidity associated with such a major procedure.

Interstitial radiotherapy (brachytherapy)

With interstitial radiotherapy neurosurgery interfaces with radiotherapy for the treatment of recurrent brain tumours. The method allows high doses of radiation to be given safely to a tumour despite previous external beam radiotherapy.⁴ The tumour mass is first imaged stereotactically—most conveniently with a relocatable device as shown in figure 2—so that its volume can be estimated (figs 3 and 4). Scanning is usually done by computed tomography though magnetic resonance imaging can also be used. The operation is then planned, and up to four external catheters are inserted stereotactically into the tumour. Seeds of radioactive iodine-125 may then be loaded into the tumour via a catheter, providing interstitial radiotherapy for five to seven days after implantation.

Radiosurgery

Radiosurgery was pioneered by Professor Leksell at the Karolinska Institute, Stockholm. Intense beams of γ radiation from 201 sources of cobalt-60 are closely collimated and focused to treat deep seated inoperable lesions, particularly arteriovenous malformations. The initial Swedish results are promising but the apparatus is expensive and complex, and an ordinary linear accelerator, accurately collimated and used stereotactically, can provide external radiosurgery for small benign tumours and angiomas and may be as effective.⁵ Both techniques are currently in use and are minimally invasive, not needing surgical incisions and requiring only local anaesthesia. Complications may arise, however, because of radionecrosis.

Endoscopic neurosurgery

Endoscopic neurosurgery was first performed in Britain by Dickson Wright at Maida Vale Hospital in 1926, when he used a cystoscope to introduce instruments to coagulate the choroid plexus in a case of hydrocephalus. The technique was adapted by Griffith in Bristol,⁶ and more recently both flexible and rigid endoscopes have been coupled with stereotactic localisation to reach fluid filled cavities such as the ventricular system or cystic tumours.⁷ This technique of minimally invasive neurosurgery is developing rapidly, with improved optics and instrument technology widening the potential for endoscopic interventions.

FIG 5—Postoperative coronal brain scan (T1 weighted magnetic resonance imaging) showing removal of epileptogenic mesial temporal structures—hippocampus and amygdala—by highly selective stereotactic operation. Only minimal removal of lateral temporal neocortex is required

Interventional neuroradiology

Neuroradiologists can now introduce fine catheters into almost any vessel in the cranium, and such vessels can be embolised, blocked with glue, or dilated with a balloon.⁸ Inoperable aneurysms, large arteriovenous malformations, and carotico-cavernous fistulae can now be treated with such minimally invasive techniques with an average morbidity similar to that associated with routine carotid angiography.

Functional neurosurgery

Most functional neurosurgical procedures—neurosurgical operations designed to improve movement disorders, epilepsy, or pain—used to rely on destructive lesions, but recently augmentative functional

neurosurgery has been developed. This depends mainly on implanted neurostimulating electrodes so that severe intractable chronic pain may be treated by spinal cord or deep brain stimulation⁹ and movement disorders by thalamic stimulation.¹⁰ New minimally invasive techniques also allow smaller selective resections to be made in selected cases of epilepsy surgery (fig 5).

Frameless stereotaxy and robotics

In frameless stereotaxy the rigid attachment of stereotactic apparatus to a patient's head during surgery is dispensed with. Instead, landmarks in the patient's skull and brain are used to register the scan images with anatomical brain structures with an accuracy which approaches that obtained by existing methods.¹¹ Technical developments in this area will probably result in minimally invasive techniques being introduced more widely into general neurosurgery. In the future the increasing application of techniques derived from robotic engineering should allow a degree of automation in operations such as brain biopsy.

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SOUND BITES

A hospital administrator worth his weight in gold

Research at Victoria Hospital in Dichpalli, India, radically changed thinking on the transmission of leprosy. It was inspired by the late Dr Frank Davey and nurtured by Dr R J W Rees, formerly director of the Medical Research Council's Mycobacterium Research Unit. The team, in which I participated examining noses and taking smears and biopsies, showed that in early lepromatous leprosy the nasal discharge is the prime source of exit of *Mycobacterium leprae* from the body and contains many millions of viable bacilli often before any gross systemic features are obvious.

Victoria Hospital is three hours by road from Hyderabad, the nearest airport, which is two hours by air from Delhi, which, in turn, is 10 hours from London. The hospital secretary, Lieutenant Colonel Lawrie Ponnaiya was responsible for arranging safe transport of fresh nasal biopsies and sealed specimens of nasal discharge from Dichpalli to Delhi to catch the overnight flight and arrive fresh in London within 24 hours for inoculation into immune deficient mice. Given the intermittency of the public power supply and the capricious nature of the hospital generator even guaranteeing the necessary supply of ice was a minor miracle but, to my knowledge, not one specimen went astray.

An equally great service to the hospital and community

lay in Colonel Ponnaiya's sporting interests. As Lawrie first showed me around Victoria Hospital we passed an open area and I remarked that it might make a good cricket pitch. His eyes lit up and in rapid time a ground, matting, nets, and the necessary equipment were in place.

After some practice a team from the nearest town, Nizamabad, accepted our invitation to visit and subsequently we played the return fixture. From the first match, held on New Year's Day 1973, the hospital team consisted of patients and staff and never has there been resistance to the stipulation that all are to be treated equally, both on and off the field. The team has now travelled extensively, in friendly and tournament competitions, throughout Andhra Pradesh with immense benefit to the morale of patients and staff. The matches have enhanced public awareness of the true nature of leprosy as a curable illness that, with early diagnosis and treatment, should carry no social stigma.—REX BARTON is a consultant ear, nose, and throat and a head and neck surgeon in Leicester

We welcome contributions to fillers: *A patient who changed my practice; A paper that changed my practice; A memorable patient; The message I would most like to leave behind*, or similar topics.