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The Role Of Major Intracranial Electrodes In Presurgical Assessment For Resective Surgery

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INTRODUCTION

The use of major intracranial recording has declined over the last 5 - 10 years with the improvements in direct brain imaging. It should only be used in the context of a comprehensive epilepsy surgery programme. In our presurgical assessment programme non-invasive and simple invasive tests such as foramen ovale telemetry are undertaken in Phases 1A and 1B before proceeding to complex invasive electrodes which constitute Phase 2.[1] The available electrode technology consists of subdural electrodes which are placed in the subdural space and depth electrodes which are inserted into and through the substance of the brain. On some occasions they may be mixed. Subdural electrodes are the more recent technique relying upon modern materials such as Silastic for their construction. Both kinds of electrodes suffer the same limitations in time and space. They can only record whilst they are in the patient and from the areas of brain with which they are in contact. Therefore it is essential to have a clear idea of the question which is to be answered and to be sure that it cannot be answered by any other method. There are also time constraints imposed by considerations of patient risk and comfort, and economics, which make it necessary to withdraw anti-epileptic drugs. This should not be commenced immediately and drugs should be withdrawn slowly. The aim should be to produce the patient's habitual attacks and avoid some of the possible problems of drug withdrawal such as confusional state or psychosis.

The intracranial recording must be part of a videotelemetry setup the important point is to provide correlation between the patient's seizures and electrical events within their brain. Wherever possible direct interactive observation of the patient at the time of the attack gives the best information but considerable information can be obtained by videotelemetry especially if the personnel are trained in positioning and observing the patient during a seizure. Once the recordings are made their analysis is very labour intensive and requires a considerable degree of technical and neurophysiological expertise. The overall effectiveness of intracranial recording is described by Behrens et al. who implanted 160 patients between 1987 and 1992 with major intracranial electrodes after ictal scalp EEG had failed to indicate the source of the patient's seizures.[2] A resective focus was found in 89% of patients but surgery was denied to 11% of the group.

INTRACEREBRAL (DEPTH) ELECTRODES

Electrodes are inserted bilaterally, usually into the temporal lobes, using stereotactic techniques. There are three approaches, orthogonal, posterior and coronal. More recently direct brain imaging using CT and MRI have been used and it is possible to visualise electrodes postoperatively in the MRI and confirm their location.[3,4] In a number of papers over many years it has been shown that locating seizure foci by depth electrodes identifies patients who are suitable for resective surgery, at any rate in the temporal lobe. With sophisticated MRI and simple videotelemetry using sphenoidal or foramen ovale electrodes the number of patieents needing depth electrodes is probably around 10%. Early findings of the results of depth electrode exploration were reported by Lieb et al.[5] Engel subsequently explored the relationship between the results of (stereoelectroencephalography) SEEG and FDG-PET, finding that in only 3/37 cases where FDG-PET was lateralising was the SE-

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EG not lateralising but was unhelpful.[6] There are many papers on this topic but typical of recent findings are those of Saint-Hilaire et al. describing their experience with 73 patients, the EEG and SE-EG were concordant in only 38% of patients[7] Cascino has recently published an evaluation of SEEG in patients in whom surface/sphenoidal telemetry had failed to provide lateralisation. Thirty patients were explored and 25 were found to have a predominantly unilateral seizure onset. The outcome of resective surgery in 21 patients with sufficient follow-up was 43% Engel Gp I and a further 14% were Engel Gp II.[8] Factors associated with a good outcome were a long inter-hemispheric transfer time and evidence of unilateral MTS. Debets et al. studied 22 patients and found concordance between SEEG localisation and CT in 23%, SEEG and MRI findings in 50% and SEEG and FDG-PET n 79% of these patients.[9] Some centres have used combinations of depth and subdural electrodes, Spencer et al. report the results of such explorations in 47 patients.[10] Seizure localisation was possible in 33 patients, consistently by the depth electrodes in 23 patients(49%), but only consistently by subdural electrodes in four patients(8%). A similar report was made by Van Veelen et al. about 28 patients.[11]

COMPLICATIONS

Creutzfeld-Jacob disease may be introduced into the brain by re-use of electrodes.[12] The only way to avoid this is by never re-using intracranial electrodes.

Centres using depth electrodes report an incidence of bacterial infection of about 2%. Van Buren reporting the cumulative data from 879 patients pooled from 14 centres has a rate of 1.3%,[13] later figures by Pilcher et al. give an average of 1.75%.[14]

Other complications of depth electrode insertion relate to the approach used for insertion. There are three common approaches, the orthogonal approach, in which the electrodes are inserted from a lateral direction, the axial approach in which they are inserted parallel to the midline usually through bifrontal entry points and the posterior approach in which they are inserted along the length of the hippocampus from an occipital entry point. This latter has produced visual field defects which are not seen with other approaches.[15] Neurological deficit can occur as a consequence of depth electrode insertion presumably due to haemorrhage either occult or overt. In the orthogonal approach, where major vessels are certain to lie in the trajectory of the electrode, it is essential to carry out stereoangiography, especially if the entry points are through twist-drill holes. Even in this situation demonstrable haemorrhage is rare and has been reported in 1%. The overall incidence of cerebral haemorrhage in the pooled data collected by Van Buren in 1987 was 1.9% for transient haemorrhage with permanent effects in 0.8%.[13] Pilcher et al. suggest that the incidence of cerebral haemorrhage is less when the orthogonal approach is used(1-2%) than when other approaches are used(2-3%) although why this is so is not clear.[14]

It would be logical to suppose that the complication rate for the use of depth electrodes will be related to the number of penetrations and therefore some have sought to reduce this risk by using combined subdural and depth electrodes. Van Veelen et al. using no more than two electrodes per side in twenty eight patients report no haemorrhage.[11]

SUBDURAL STRIPS AND GRIDS(MATS)

These have more varied application than the intracerebral depth electrodes. In some centres subtemporal subdural strips will be used in circumstances where others would use ictal sphenoidal or foramen ovale electrodes. They are effective, especially if the electrodes are designed in such a way as to reach the parahippocampal gyrus.[6] However, because of patterns of seizure spread, subdural strips in the temporal lobe may give false information.[10,17] Beyond that the use of subdural electrodes, especially the larger grids such as 8 X 8 (64 contact) are generally unilateral and serve a number of purposes. These include assessment, in relation to the kind of conceptual considerations reviewed by Lüders, of the physiological parameters associated with focal cortical epilepsy.[18] They can be used for cortical stimulation and thereby map primary motor and sensory areas and speech areas. Indeed whereas their general use was described by Wyler in 1984[19] they were also employed by

Goldring in the epidural space in children where mapping under local anaesthesia would be impossible.[20] They can be localised precisely by co-registration with MRI, and other information can be also be co-registered.[21]

The results of using these electrodes in evaluating temporal lobe epilepsy in 89 patients was published in 1992.[22] A good outcome was associated with unilateral onset not accompanied by frontal desynchronisation and an interhemispheric propagation time greater than 8 seconds. Jennum et al. described the results of resections guided by the results from subdural recordings.[3] They found that a good outcome was associated with the ability to resect both inter-ictal and ictal active areas. In 1991 the Cleveland Clinic published the results of 47 patients investigated with subdural grids over a variety of areas.[24] They analysed the results with regard to the ability to resect the lesion completely and to resect the seizure focus completely. They also note that mapping by stimulation enabled them to plan which areas were unresectable. In 18 patients where the lesion was resected completely seizure control was achieved in 94%, in six patients where the lesion resection was incomplete but the seizure focus resection was complete seizure control was achieved in 83% and in 23 patients where both resections were incomplete, seizure control was only seen in 52%.

COMPLICATIONS

The complications increase with the size and number of electrodes and the duration of implantation. Subdural or subarachnoid haemorrhage is rare, electrodes should be advanced with caution to inaccessible areas, such as the medial surface of the hemisphere. Blood collecting in the subdural or extradural space is uncommon with careful technique and discouraged by the bulk of the electrodes. Wyler et al. report no such complications in 350 patients.[25]

Infection is clearly a risk which can be minimised by three manoeuvres, the use of antibiotic cover, bringing the cables through an incision remote from the main incision, and minimising the duration of the implantation. If possible, the definitive procedure should be performed when the electrodes are removed. Dural closure is rarely a problem but there is potential CSF leakage along the cables. Elevation of the head and changing of soiled dressings is all that can be done to control this. On one occasion out of 35 major grid implantations we have seen significant brain swelling. Frank meningitis or other intracranial infection following subdural implantation is rare. Wyler reported that they had an overall infection rate of 0.85% and that the particular antibiotic (cefazolin) which was given to half of the patients had no influence on this infection rate. The average implantation time in their series was 4.5 days, we try to keep it to less than 4 days.[25] In our patients the infection has usually been in the extradural space and may necessitate removal of the flap and subsequent cranioplasty.

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