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COMPREHENSIVE REVIEW

Planning and management of SEEG

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Summary Stereoelectroencephalography (SEEG) aims to define the epileptogenic zone (EZ), to study its relationship with functional areas and the causal lesion and to evaluate the possibility of surgical therapy. Planning of exploration is based on the validity of the hypotheses developed from electroclinical and imaging correlations. Further investigations can refine the implantation plan (e.g. fluorodeoxyglucose positron emission tomography [FDG-PET], single photon emission computerized tomography [SPECT], magnetoencephalography [MEG] and high resolution electroencephalography [EEG-HR]). The scheme is individualized according to the features of each clinical case, but a general approach can be systematized according to the regions involved (temporal versus extra-temporal), the existence of a lesion, its type and extent. It takes account of the hemispheric dominance for language if this can be determined. In ''temporal plus'' epilepsies, perisylvian and insular regions are among the key structures to investigate in addition to mesial and neocortical temporal areas. In frontal lobe epilepsies, determining the functional and anatomical organization of seizures (anterior versus posterior,

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mesial versus dorsolateral) allows better targeting of the implantation. Posterior epilepsies tend to have a complex organization leading to multilobar and often bilateral explorations. In lesional cases, it may be useful to implant one or several intralesional electrode(s), except in cases of vascular lesions or cyst. The strategy of implantation can be modified if thermocoagulations are considered. The management of SEEG implies continuous monitoring in a dedicated environment to determine the EZ with optimal safety conditions. This methodology includes spontaneous seizure recordings, low and high frequency stimulations and, if possible, sleep recording. SEEG is applicable in children, even the very young. Specific training of medical and paramedical teams is required.

Introduction

The aim of SEEG is to determine the location of the epileptogenic zone (EZ) and the propagation pathways in order to perform a surgical treatment. While the concept and definition of EZ has been subject to some controversy according to different schools of epileptology, the present work refers to the definition developed by the founders of the SEEG methodology and is based on neurophysiological criteria [1—6]. The EZ integrates the site of onset and primary organization of ictal discharges and their correlation with clinical expression, interictal electrical abnormalities and anatomical data. Analyzing the spatial-temporal dynamic of ictal events is crucial for defining the EZ. Once established, relationships between the EZ and functional anatomical structures, and feasibility of surgical resection or disconnection have to be evaluated. Thus the strategy of implantation must meet the following objectives: (1) to define the EZ at the neurophysiological level, (2) to study its relations with highly functional areas and the causal lesion if identified and (3) to evaluate the possibilities of surgical treatment. The management of SEEG implies the determination of EZ with optimal security conditions. The training of medical and paramedical teams is included in these recommendations.

Methods

As in other chapters related to SEEG methodology, recommendations concerning the planning and management of the exploration were drawn from the experience of the teams confronted in a consensus meeting and supported by the data from existing literature. We identified references from PubMed with the terms ''stereo-EEG'', ''stereo-electroencephalography'', ''SEEG'', ''invasive recordings'', ''epileptogenic zone'', ''electrical stimulations'', ''epilepsy surgery'', ''partial seizures'', ''temporal lobe epilepsy'', ''frontal lobe epilepsy'', ''parietal lobe epilepsy'', ''occipital lobe epilepsy'', ''insular epilepsy'', ''hippocampal sclerosis'', ''malformation of cortical development'', ''focal cortical dysplasia'', ''cryptogenic epilepsy'', ''negative MRI'' in various associations, without time limit and including articles in French and English. The final list was established on the basis of the SEEG-specific reference including historical data, with relevance to current practices.

We will successively examine the consensus recommendations concerning (1) pre-implantation assessment (phase 1); (2) planning of implantation according to the presumed location and lateralization of the EZ; (3) particular aspects according to the underlying cause of epilepsy (lesional versus non-lesional; (4) specificities of management in children and (5) training of personnel.

Pre-implantation assessment

Since the first recordings and the development of the methodology by the pioneers of SEEG, widespread improvement of techniques and practices has progressively been adopted, while remaining faithful to the initial concepts. The pre-implantation assessment is currently well codified although resources may vary significantly from one center to another, as evidenced by a recent European survey [7]. Seizure recordings with EEG-video monitoring and high quality MRI constitute the minimum base that is mandatory for planning SEEG. Morphological imaging techniques are regularly improved according to technological advances [8—10]. Protocols dedicated to epilepsy must be available. Other non-invasive techniques have proved to be useful to localize the EZ and to refine the implantation strategy, especially in negative-MRI cases (PET with 18F-fluorodeoxyglucose (FDG) [11—15]; SPECT during the ictal period, compared to interictal examination [16]; MEG [17,18]; and electrical source imaging with EEG-HR [19—22]. The multimodal approach seems the most attractive but requires access to highly specialized and expensive equipment. However, the respective contribution of each tool is not formally established to date. If the patient's age and possibilities of cooperation allow it, performing a neuropsychological assessment and/or functional MRI (fMRI) may be useful at this stage in determining hemispheric dominance for language and anticipating the functional consequences of the surgical resection. However, this point of view was not shared by all teams, especially pediatric teams, since fMRI is not feasible in a number of situations.