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Preface xi
John S. Duncan

MR Imaging of Epilepsy: Strategies for Successful Interpretation 349
Venkatramana R. Vattipally and Richard A. Bronen

The first half of this article is devoted to providing an introduction and overview for MR imaging of epilepsy. Several MR imaging epilepsy topics will be discussed in great detail in separate articles, such as hippocampal sclerosis, developmental disorders, and functional MR imaging. The remainder of this review will discuss strategies for successful interpretation of MR images from the seizure patient and how to avoid potential pitfalls.

Qualitative and Quantitative Imaging of the Hippocampus in Mesial Temporal Lobe Epilepsy with Hippocampal Sclerosis 373
Wim Van Paesschen

MR imaging allows the in vivo detection of hippocampal sclerosis (HS) and has been instrumental in the delineation of the syndrome of mesial temporal lobe epilepsy with HS (mTLE-HS). MR features of HS include hippocampal atrophy with an increased T2 signal. Quantitative MR imaging accurately reflects the degree of hippocampal damage. Ictal single photon emission computed tomography (SPECT) in mTLE-HS shows typical perfusion patterns of ipsilateral temporal lobe hyperperfusion, and ipsilateral frontoparietal and contralateral cerebellar hypoperfusion. Interictal ^{18}fluoro-2-deoxyglucose positron emission tomography (PET) shows multiregional hypometabolism, involving predominantly the ipsilateral temporal lobe. ^{11}C-flumazenil PET shows hippocampal decreases in central benzodiazepine receptor density. Future strategies to study the etiology and pathogenesis of HS should include longitudinal MR imaging studies, MR studies in families with epilepsy and febrile seizures, stratification for genetic background, coregistration with SPECT and PET, partial volume correction and statistical parametric mapping analysis of SPECT and PET images.

Malformations of Cortical Development 401
Anthony James Barkovich and Charles A. Raybaud

Malformations of cortical development are important causes of developmental delay and epilepsy. They are classified by the presumed stage during which normal development is interrupted: neuronal proliferation and differentiation; neuronal migration; and late migration/cortical organization. The important malformations in each of these groups are

discussed in this article, along with a discussion of how and why the malformations develop, and their imaging findings. A better understanding of these disorders helps in genetic counseling and may help in the treatment of associated epilepsy.

Quantitative MR Imaging of the Neocortex 425
Andrea Bernasconi

This article provides an overview of novel MR image analysis methods applied to the quantitative assessment of the neocortex in various forms of epilepsy. Postacquisition processing methods, such as voxel-based morphometry and texture analysis, involve the use of computer software to manipulate, enhance, and classify image information in a digital format. These techniques have the potential to demonstrate subtle abnormalities that are not identified by eye because of anatomic variability. Information provided by quantitative MR imaging of the neocortex may be important for the identification of accurate predictors of surgical outcome and may refine the selection of surgical candidates, particularly those with "nonlesional" neocortical epilepsy.

Serial Imaging of the Brain 437
Rebecca S.N. Liu

Serial MR imaging studies incorporating region- and voxel-based methods allow the identification and quantification of secondary cerebral damage caused by seizures. Postprocessing tools, including rigid-body and nonrigid registration have increased sensitivity to subtle structural change by reducing the variability of measurement techniques. In this article, methodologic aspects, such as coregistration and difference image analysis, and the tools used for serial volumetry are covered, together with their application in the investigation of seizure-related damage. The role of novel MR contrasts in addressing acute changes and subtle neuronal injury is also presented.

Novel MR Contrasts to Reveal More About the Brain 449
Fergus J. Rugg-Gunn and Mark R. Symms

Twenty percent of patients with refractory focal epilepsy have an undetermined etiologic basis for their epilepsy despite extensive investigation, including optimal MR imaging. Surgical treatment of this group is associated with a less favorable postoperative outcome. Even with improvements in imaging techniques, a proportion of these patients will remain "MR imaging-negative." It is likely, however, that some of the discrete macroscopic focal lesions that are currently occult will be identified by imaging techniques interrogating different microstructural characteristics. Furthermore, these methods may provide pathologic specificity when used in combination. The description and application of these techniques in epilepsy are the focus of this article.

Functional MR Imaging of Language, Memory, and Sensorimotor Cortex 471
William Davis Gaillard

Functional magnetic resonance imaging (fMR imaging) is employed to identify eloquent cortex to be spared during epilepsy surgery, principally the primary motor and sensory cortex, and brain areas implicated in language and memory. fMR imaging language paradigms have 90% concordance with intracarotid amobarbital tests (IAT) for identifying the dominant hemisphere for language; partial disparity occurs in 10% of patients; and overt discordance is rare but may occur under recognizable circumstances. The few studies to directly compare electrocortical stimulation with fMR imaging show a specificity of

67% and a sensitivity of over 90%. fMR imaging of memory paradigms demonstrate activation in mesial temporal structures but are not yet validated for individual patient surgical planning.

Electroencephalography-Correlated Functional MR Imaging Studies of Epileptic Activity 487
Louis Lemieux

This article focuses on the use of combined electroencephalography and functional MR imaging (EEG-fMRI) as a tool to investigate the relationship between epileptiform discharges and hemodynamic changes. Essentially a functional MR imaging technique, EEG-fMRI can provide whole-brain maps of those changes, and hence has the potential to give a new form of localizing information on the generators of epileptiform discharges. The author briefly reviews the problem of localization in epilepsy and, in particular, the roles of EEG and functional MR imaging, and then discusses the motivations for combined EEG and functional MR imaging experiments, the possible ways in which the data can be acquired, and the associated technical requirements. This is followed by a presentation of the analysis methods used and a discussion of the applications of EEG-fMRI in epilepsy. An overview and discussion of the main findings and ideas for future research is also provided.

Clinical Applications of MR Spectroscopy in Epilepsy 507
Ruben Kuzniecky

In vivo MR spectroscopy (MRS) offers the unique ability to noninvasively measure the chemical composition of living tissue. Available for measurement are metabolites and neurotransmitter concentrations, lactate, pH, energy metabolism, and even metabolic rate constants that are fundamental to brain function and of importance in disease. In this article, the major applications of MRS in epilepsy are reviewed, with emphasis on clinical utility, correlative studies, and future directions.

The Role of Positron Emission Tomography with [^{18}F]fluorodeoxyglucose in the Evaluation of the Epilepsies 517
Thomas R. Henry and John R. Votaw

Cerebral glucose metabolic mapping using positron emission tomography (PET) and 2-[^{18}F]fluoro-2-deoxyglucose (FDG) has been extensively studied in the epilepsies. Regions of interictal glucose hypometabolism are highly associated with cerebral sites of seizure generation-propagation in focal epilepsies. The volume of reduced glucose metabolism is often widespread and even bilateral in focal epilepsies, although ictal onset zones typically are located at the sites of most severe hypometabolism within a larger volume of hypometabolism.

Flumazenil Positron Emission Tomography and other Ligands for Functional Imaging 537
Alexander Hammers

Positron emission tomography (PET) enables tomographic imaging of local concentrations of injected biologically active substances that have been radioactively labeled (radioligands; tracers). Patients can be investigated in the resting state or in relationship to an event (eg, injection of a drug or occurrence of a seizure). This article discusses the use of flumazenil PET and other ligands in focal and idiopathic generalized epilepsies.