Clinical MR Spectroscopy

Techniques and Applications

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Preface

Magnetic resonance spectroscopy (MRS) allows the non-invasive measurement of selected biological compounds in vivo. Feasibility was first demonstrated in humans in the mid-1980s. Since that time, much experience has been accumulated with the use of MRS in both research and clinical applications. Nearly all magnetic resonance imaging (MRI) scanners have the capability to perform MRS, and MRS techniques still continue to improve, even after two decades of development. MRS has been applied to the study of all major pathologies, particularly in the brain, but has also found application in other organ systems as well, most notably in the breast and prostate.

In spite of this considerable research effort and the unique biochemical information provided, only limited integration of MRS into clinical practice has occurred to date. There are multiple reasons for this, including non-standardization of acquisition and analysis protocols, limited vendor support, difficulties in interpretation (particularly for radiologists without a background in MRS), limited perceived "added-value" above conventional MRI, and lack of reimbursement.

This book is intended to address some of these issues. It gives the reader a solid basis for understanding both the techniques and applications of clinical MRS. Recommendations are made for MRS protocols, and information provided on normal regional- and age-related metabolic variations in the brain. Detailed information about the role of MRS in evaluating pathologies involving the central nervous system, breast, prostate, and musculoskeletal systems is provided. The book also discusses the limitations of MRS, such as its low spatial resolution (e.g. compared to MRI), common artifacts, and diagnostic pitfalls.

The aim of this book is to provide a practical reference work that covers all aspects of in vivo spectroscopy in humans for clinical purposes. As such, it should be a useful guide for radiologists, oncologists, neurologists, neurosurgeons, and other physicians who may be interested in using MRS in their practices. We hope that more widespread adoption of MRS into the clinic will lead to better diagnoses and improved outcomes for individual patients.

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PBB	For Catherine and Stephanie
AB	For Anna, Lorenza, and Caterina, who allowed me to devote energy and time to this project
NDS	For Simona, Giorgio, and Andrea
RPG	For Asha. For her enormous patience!
DDML	In loving memory of my father, Daniel

Abbreviations

AD	Alexander disease
AD	Alzheimer's disease
ADC	apparent diffusion coefficient
ADEM	acute disseminated encephalomyelitis
AIS	Abbreviated Injury Scale
ALS	amyotrophic lateral sclerosis
ATP	adenosine triphosphate
CBD	corticobasal degeneration
CBF	cerebral blood flow
CIS	clinically isolated syndrome
CRB	Cramer–Rao bounds
CSD	cortical spreading depression
CSF	cerebrospinal fluid
CSI	chemical shift imaging
CW	continuous wave
DAI	diffuse axonal injury
DLB	dementia with Lewy bodies
DRN	delayed radiation necrosis
DTI	diffusion tensor imaging
DWI	diffusion-weighted imaging
ECD	Erdheim–Chester disease
EPSI	echo-planar spectroscopic imaging
FFI	fatal familial insomnia
FFT	fast Fourier transformation
FID	free induction decay
FOV	field of view
FSE	fast spin echo
FT	Fourier transform
FTD	frontotemporal dementia
GAMT	guanidinoacetate methyl transferase
GCS	Glasgow Coma Scale
GPC	glycerophosphocholine
GSD	Gerstmann–Straussler disease
HE	hepatic encephalopathy
HGG	high-grade glioma
HIE	hypoxic–ischemic encephalopathy
HPD	human prion disease(s)
ICA	internal carotid artery
IVS	inner volume suppression
LGG	low-grade glioma
LOH	loss of heterozygosity
MCA	middle cerebral artery
MCD	malformations of cortical development
MCI	mild cognitive impairment
MEG	magnetoencephalography
mI	*myo*-inositol
MOA	mixed oligoastrocytoma
MRI	magnetic resonance imaging
MRS	magnetic resonance spectroscopy
MRSI	MR spectroscopic imaging
MSA	multiple system atrophy
MSM	methyl-sulfonyl-methane
MTR	magnetization transfer ratio
MTS	mesial temporal sclerosis
NAA	*N*-acetylaspartate
NMR	nuclear magnetic resonance
OVS	outer-volume suppression
PC	phosphocholine
PCPCS	Pediatric Cerebral Performance Category Scale
PCr	phosphocreatine
PDE	phosphodiesters
PET	positron emission tomography
Pi	inorganic phosphate
PLIC	posterior limb of the internal capsule
PME	phosphomonoesters
PML	progressive multifocal leukoencephalopathy
PNET	primitive neuroectodermal tumors
PRESS	Point REsolved Spectroscopy Sequence
PSF	point spread function
PSP	progressive supranuclear palsy
RE	Rasmussen's encephalitis
RF	radiofrequency
SAR	specific absorption rate
SIAM	spectroscopic imaging acquisition mode
SMA	supplementary motor area
SNR	signal to noise ratio
SPECT	single photon emission computed tomography
SSPE	subacute sclerosing panencephalitis
STEAM	stimulated echo acquisition mode
SVZ	subventricular zone

Abbreviations

SWI	susceptibility-weighted imaging	VD	vascular dementia
TBI	traumatic brain injury	VOI	volume of interest
TLE	temporal lobe epilepsy	VWM	vanishing white matter
TMS	tetramethylsilane	VZ	ventricular zone