

Proton MR Spectroscopy and Diffusion weighted-imaging in Hepatic Encephalopathy

Thesis

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Abstract

Hepatic encephalopathy (HE) is a frequent complication of chronic liver disease. It is defined as a characteristic functional and reversible alteration of the mental state, due to impaired liver function and/ or increased portosystemic shunting. MR imaging and proton MR spectroscopy (^1H MRS) brain abnormalities have been described in association with chronic liver disease. Brain water apparent diffusion coefficient is increased in patients with chronic liver disease and may be useful in monitoring patients with HE.

Key words: Hepatic encephalopathy, chronic liver disease, MR imaging, proton MR spectroscopy, apparent diffusion coefficient.

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List of Abbreviations

Abbreviation	Full name
AA	Anaplastic astrocytoma
AA	Aromatic amino acids
AChE	Acetylcholinesterase
ACHF	Acute-on-chronic hepatic failure
ACLF	Acute-on-chronic liver failure
ADC	analog–digital-convertors
ADC	Apparent diffusion coefficient
ADHD	Attention-deficit hyperactivity disorder
AHF	Acute hepatic failure
AIDS	Acquired immune deficiency syndrome
Ala	Alanine
ALIC	Anterior limb of internal capsule
ALF	Acute liver failure
ANOVA	Analysis of variance
AQP	Aquaporins
Asp	Aspartate
ASSET	Array spatial sensitivity encoding technique
ATP	Adenosine triphosphate
BBB	Blood brain barrier
BCAAs	branched-chain amino acid
BG	Basal ganglia
BO	Magnetic field
BPAD	Bipolar affective disorder

^{13}C	Carbon atom
Ca^2	Calcium
CC	Corpus callosum
CBF	Cerebral blood flow
CE	Cerebral edema
CHE	Chronic hepatic encephalopathy
Cho	choline
Cho/Cr	Choline/Creatine
CLD	Chronic liver disease
CLF	Chronic liver failure
CO_2	Carbon dioxide
COOH	Carboxyl group
CL	Linear anisotropy
cMRI	Conventional Magnetic resonance imaging
CNS	Central nervous system
Conc	Concentration
CP	planar anisotropy
Cr	Creatine
Cr/PCr	Creatine/phosphocreatine;
CS	spherical isotropy
CsA	Cyclosporin A
CSF	Cerebro-spinal fluid
CSI	Chemical shift imaging
CT	Computed tomography
CV	Coefficient of variation

D	Diffusion coefficient
d	Mean diameter of the three-dimensional extension of the molecular motion
d	Doublet
dd	Doublet of doublet
DA	Dopamine
DTI	Diffusion tensor imaging
DT MRI	Diffusion tensor magnetic resonance imaging
DW-EPI	Diffusion-weighted echo-planar imaging
DWI	Diffusion-weighted imaging
ECF	Extracellular fluid
ECS	Extracellular space
EEG	Electroencephalography
ERK	Extracellular signal-regulated kinase-1
ESLD	end-stage liver disease
f	frequency
¹⁹ F	Fluorine atom
FA	Fractional anisotropy
Fast-FLAIR	Fast-Fluid attenuation inversion recovery
FHF	Fulminant hepatic failure
FID	Free induction decay
FLAIR	Fluid attenuation inversion recovery
FN	False negatives
FOV	Field of view
FP	False positives
FSE	Fast spin-echo imaging .

FT	Fourier Transform
FWHM	full width at half maximum
FWM	Frontal white matter
γ	gyromagnetic ratio
GABA	Gamma-aminobutyric acid
GCS	Glasgow Coma Scale
GFAP	Glial fibrillary acidic protein
Glc	Glucose
GLN	Glutamine
Gln/Glx	Glutamine-glutamate
Glx	Glutamine-glutamate
GPCho	glycerophosphorylcholine
GLU	Glutamate
Glx	Glutamine-glutamate
Glx/Cr	Glutamine/Creatine
GP	Globi pallidi
GRAPPA	Generalized auto-calibrating partially parallel acquisitions
GRC	GABA-A receptor complex
GS	Glutamine synthetase
^1H	Hydrogen atom
HE	Hepatic encephalopathy
HPR	hypothalamic pituitary region
^1H MR	Proton magnetic resonance
^1H MRS	Proton magnetic resonance Spectroscopy
^1H NMR	Proton nuclear magnetic resonance

ICS	intra-cellular space
IL	Interleukin
Ins	Myo-inositol
ISHEN	International Society for Hepatic Encephalopathy and Nitrogen Metabolism
ICP	Intracranial hypertension
Lac	Lactate
LCH	Langerhans cell histiocytosis
LCModel	Linear Combination of Model Spectra
LDLT	Live-Donor liver transplantation
Lip	Lipid
LOLA	L-Ornithine L-Aspartate
LT	Left
LT	Liver transplantation
MAO	Monoamine oxidase
MD	Mean diffusivity
MKK4	Mitogen-activated protein/Erk kinase-4
MHE	Minimal hepatic encephalopathy
mI	myo-inositol
mIns	myo-inositol
mI +Cho/Glx	myo-inositol +Choline/Glutamine Glutamate
mIns/Cr	myo-inositol/Creatine
Mn ²⁺	Manganese
MELD	model for End Stage Liver Disease
MPT	Mitochondrial permeability transition
MR	Magnetic resonance

MRI	Magnetic resonance imaging
MRS	Magnetic resonance Spectroscopy
MRSI	Magnetic resonance spectroscopic imaging
MT	Magnetisation transfer
MTR	Magnetisation transfer ratio
MRUI	Magnetic Resonance User Interface
N/2	Nyquist
²³ Na	Sodium atom
NAA	N-acetyl-aspartate
NAA/Cr	N-acetyl-aspartate/Creatine
NAAG	N-acetyl aspartate glutamate
NAWM	Normal-appearing white matter
NEX	Number of excitations
NH ₃	Ammonia
NH ₃ -	Amide group
NMDA	N-methyl-D-aspartate
NMR	Nuclear magnetic resonance
NOS	Nitric oxide synthases
NP	neuropsychological
NPN	Negative predictive value
OTC	Ornithine transcarbamylase
OWM	Occipital White matter
³¹ P	Phosphorus atom
PAG	Phosphate-activated glutaminase
PAL	Performance Assessment Logic

PBR	Peripheral benzodiazepine receptors
PCho	phosphorylcholine
PET	Positron emission tomography
PLIC	Posterior limb of internal capsule
ppm	Parts per million
PPV	Positive predictive value
PRESS	Point resolved spectroscopy sequence
PTN	Protein tyrosine nitration
PVWM	Periventricular white matter
RA	Relative anisotropy
RF	Radio-frequency
rCBV	Relative cerebral blood volume
ROIs	Region-of-interests
RNA	Ribonucleic Acid
ROS/RNOS	Reactive oxygen and nitrogen oxide species
RT	Right
s	singlet
SBP	Spontaneous bacterial peritonitis
SD	Standard deviation
SE	Spin-echo
SENSE	Sensitivity encoding
SEP	Somatosensory-evoked potential
SEK1	Stress-activated protein kinase (SAPK)/ Extracellular signal-regulated kinase-1(Erk)
SERK	Stress-activated protein kinase
SI	Signal intensity

SI	Spectroscopic imaging
SIRS	Systemic inflammatory response syndrome
SIBO	Small Intestinal bacterial overgrowth
s/mm ²	Second/millimeter square
SN	Substantia nigra
SNR	signal-to-noise ratio
SPECT	Single photon emission computed tomography
SPSS	Statistical Package for the Social Sciences
SR	Signal recovery
SS-EPI	Single-shot echo-planar imaging
STEAM	Stimulated echo acquisition mode
SVS	Single-voxel spectroscopy
t	function of time
τ	time
t	triplet
T	Tesla
Tau	Taurine
TI	Time of inversion
tCr	Total creatine
TE	Time of echo
TIPS	Transjugular intrahepatic portosystemic shunt
TIPSS	Transjugular intrahepatic portosystemic shunt surgery
TCA _{CA}	Tricarboxylic acid cycle in the astrocytic compartment
TCA _{NA}	Tricarboxylic acid cycle in the neuronal compartment
TM	Mixing time

TN	True negatives
TNF	Tumor necrosis factor
TP	True positives
TR	Time of repetition
Tr	Trace
VAPOR	Variable Pulse power and Optimized Relaxation delays
VOI	Volume of interest
VR	volume ratio
WaD	Wallerian degeneration
WM	White matter
WMLs	White matter lesions
([Zn ²⁺] _i)	Free intracellular zinc

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