

Table of contents

Authors
Collaborators
Preface
Acronyms

GENERAL SECTION

Stefano Colagrande, Pasquale Paolantonio

Symbols, acronyms, and glossary

Genesis and intrinsic parameters of signal

Introduction
 Insertion of the nuclei in the B0:
 orientation and precession
 Transmission of the RF pulse:
 excitation and phase synchronization
 Termination of the RF pulse:
 relaxation and signal formation
 Intrinsic parameters
 Spin and lattice
 T1 or spin-lattice relaxation time
 T2 or spin-spin relaxation time

Extrinsic parameters

Introduction
 Pulse repetition time
 Echo time
 Repetition time and echo time
 Flip angle
 Matrix
 Field of view
 Number of averages or number of excitations

Signal-encoding and basic K-space concepts

Introduction
 Encoding gradients
 K-space
 Gradients and conventional
 bi- and three-dimensional acquisition
 Multislice technique
 Gradients and new acquisition techniques
 K-space and temporal savings methods
 Rectangular field of view
 Scan percentage
 Half scan

Pulse sequences

Introduction
 Spin-echo sequences
 Inversion recovery sequences
 Gradient-echo sequences
 Turbo spin-echo sequences
 Various types of gradient echo
 Echo planar sequences
 Hybrid sequences
 GRE 3D sequences
*Appendix - A more detailed discussion
 about sequences*

Saturation techniques

Chemical shift
 Types of saturation techniques
 Selective fat/water saturation
 with non-Dixon techniques
 Selective saturation with Dixon technique
 Selective saturation of organic tissues
 Selective free-bound water saturation

K-space sampling strategies

Introduction
 Sampling K-space typologies
 Linear non-echo planar sampling
 Echo planar sampling
 Radial sampling
 Parallel imaging
*Appendix - A more detailed discussion
 about sequences and two FAQs*

Diffusion imaging

Introduction
 Acquisition and quantification
 Quality and reproducibility
 Intravoxel incoherent motion and Kurtosis
 DWI in everyday practice
 Type of equipment and indication of parameters
 Acquisition and breathing mode
 Extent and number of b-values
 Relationships in administering contrast medium
 and age
 Clinical utility of DWI acquisitions

MR quantification

Introduction
 Relaxometry
 T1 mapping
 T2 and T2 mapping*
 Fat fraction
 Perfusion
 Post-processing
 Semiquantitative non-parametric methods
 (model-free)
 Quantitative parametric methods
 Spectroscopy

General and flow semeiotics

Introduction
 Paramagnetic agent semeiotics
 Flow signal semeiotics
 TOF phenomena
 Phase-shift effects phenomena

Acquisition: angiography sequences

Non-contrast MR angiography
 TOF technique
 PC technique
 Other non-contrast-enhanced-MR angiography
 techniques
 Contrast-enhanced-MR angiography
 Contrast-enhanced-MR angiography sequences
 Contrast agent administration
 Black-blood sequences
 Bright-blood sequences

Equipment

Introduction
 Magnet
 Radiofrequency coils
 Gradient system

Artifacts

Introduction
 Phase
 Aliasing
 Radiofrequencies
 Movement
 Frequency
 Chemical shift
 Phase and frequency
 Gibbs truncation artifact
 Slice
 Multislice cross-talk

Independent of any encoding
 Magnetic susceptibility
 Magnetic field inhomogeneities
 MR angiography artifacts
 Maki effect
 Blurring
 Dielectric effect

MR safety

Introduction
 Static magnetic field
 Gradient magnetic fields
 Magnetic fields linked to RF
 MRI compatibility with medical devices
 and implants
 Malfunction of active devices or implants
 Pregnancy
 Contrast media and pregnancy
 Contrast media and safety

Essential references of the general section

SPECIAL SECTION**Contrast media**

*Giovanni Morana, Andrea Mazzaro,
 Alex Faccinnetto, Luigi Grazioli*

Introduction
 Mechanism of action
 Classification
 Extracellular contrast agents
 (vascular-interstitial)
 CA with intravascular distribution
 CA with organ-specific distribution
 CA with gastrointestinal distribution

SAFETY OF MRI CONTRAST AGENTS

Alfonso Ragozzino, Marta Puglia, Anna Giacomina Tucci

Introduction
 Acute adverse reactions
 Late and very late adverse reactions
 Renal adverse reactions (post-contrast acute
 renal injury)
 Recommendations for clinical practice
 Pregnancy and breastfeeding
 Gadolinium retention in the body
 The choice of gadolinium-based contrast agent
 High risk
 Intermediate risk
 Low risk

References

Liver

*Luigi Grazioli, Martina Bertuletti,
Barbara Frittoli, Giovanni Morana*

Introduction
MR technique
MR anatomy and anatomic variants of the liver

HEPATOPATHY AND CIRRHOSIS

Introduction
Diffuse liver diseases
Acute hepatitis
Chronic hepatitis
Steatosis-steatohepatitis
Cirrhosis
Cirrhosis in hemochromatosis
Hepatocellular carcinoma

NON-CIRRHOTIC AND ONCOLOGICAL LIVER

Introduction
Benign lesions
Cysts
Hamartoma
Hemangioma
Hepatocellular adenoma
Focal nodular hyperplasia
Perivascular epithelioid cell tumors
Abscesses
Inflammatory pseudotumor
Malignant lesions
Cholangiocarcinoma (intrahepatic)
Hepatic lymphoma
Rare primitive lesions
Metastases
Liver in oncological patients: clinical problems
Identification
Characterization

LIVER IMAGING REPORTING
AND DATA SYSTEM (LI-RADS) DIAGNOSTIC CRITERIA
*Federica Vernuccio, Roberto Cannella,
Giuseppe Brancatelli*

Introduction
MR LI-RADS: contexts and target population
MR features for categorization of observations
Major features
Ancillary features favoring malignancy,
not HCC in particular
Ancillary features favoring HCC in particular
Ancillary features favoring benignity
Diagnostic categories and management
Steps for assigning LR-1
to LR-5 diagnostic category
LI-RADS treatment algorithm

MR IN PEDIATRICS - Liver tumors

*Maria Pia Bondioni, Luigi Grazioli,
Francesco Acquafredda, Marcello Napolitano*

Introduction
Benign lesions
Hepatic hemangioma
Mesenchymal hamartoma
Focal nodular hyperplasia
Hepatic adenoma
Nodular regenerative hyperplasia
Malignant lesions
Hepatoblastoma
Hepatocellular carcinoma
Fibrolamellar hepatocellular carcinoma
Cholangiocarcinoma
Undifferentiated embryonal sarcoma
Biliary rhabdomyosarcoma
Angiosarcoma

*References***Portal system**

*Alfonso Ragozzino, Onorina Bruno,
Giuseppe Di Costanzo, Anna Giacomina Tucci*

Introduction
MR technique
Clinical features
Anatomical variants of the portal vein
Portal hypertension
Portal vein obstruction
Portal vein thrombosis
Portal vein thrombosis and cirrhosis
Neoplastic obstruction of the portal vein
Portosinusoidal vascular disease
Isolated thrombosis of the splenic vein
Liver transplant
Suprahepatic veins
Budd-Chiari syndrome

*References***Liver transplantation:
pre- and post-operative evaluations**

*Rita Golfieri, Alfonso Ragozzino,
Irene Pettinari, Matteo Renzulli*

Pre-operative imaging
Pre-operative evaluation
of liver transplantation candidates
Pre-operative evaluation of a living donor
Post-operative imaging
Post-transplant normal findings
Post-transplant complications

References

Gallbladder and biliary system

*Alfonso Ragozzino, Giuseppe Di Costanzo,
Marta Puglia, Anna Giacomina Tucci*

Introduction

MR technique

- Normal MR anatomy

- Anatomical variants

Non-neoplastic lesions

- Congenital anomalies

- Lithiasis

- Phlogistic pathology

Malignant lesions

- Cholangiocarcinoma

- Periampullary carcinomas

- Gallbladder carcinoma

- Polyps

- Metastasis

Post-surgical evaluation

- Post-operative complications

Traumatic injuries

- Gallbladder trauma

- Biliary system trauma

**MR IN PEDIATRICS - Choledochal cysts
and malformations**

*Maria Pia Bondioni, Alfonso Ragozzino,
Francesco Laffranchi, Marcello Napolitano*

Choledochal cysts

- Spontaneous biliary perforation

- Biliary atresia

- Alagille syndrome

- Inspissated bile plug syndrome

- Gallbladder and biliary lithiasis

- Gallbladder agenesis

*References***Pancreas**

*Giovanni Morana, Alex Faccinnetto,
Silvia Venturini, Riccardo Manfredi*

Introduction

MR technique

- Sequences

Non-tumoral lesions

- Acute pancreatitis

- Recurrent acute pancreatitis

- Chronic pancreatitis

- Paraduodenal pancreatitis

- Autoimmune pancreatitis

- Non-neoplastic pancreatic cystic lesions

Malignant lesions

- Pancreatic carcinoma

- Neuroendocrine tumors

- Neoplastic pancreatic cystic lesions

- Acinar cell cystic neoplasm

*References***Spleen**

Alessandro Stecco, Alessio Paschè

Introduction

MR technique

- Normal MR anatomy

Benign lesions

- Cysts

- Hamartoma

- Hemangioma

- Lymphangioma

Malignant lesions

- Hemangiosarcoma

- Lymphoma

- Metastasis

Vascular alterations

- Splenic infarction

- Splenic artery aneurysms

Infectious pathology

- Abscesses

- Tuberculosis

Inflammatory pathology

- Sarcoidosis

Trauma

Splenomegaly

*References***Gastrointestinal system**

ESOPHAGUS

Domenico De Santis, Andrea Laghi

Introduction

MR technique

- Organic pathology

- Motility pathology

STOMACH

Elena Lucertini, Andrea Laghi

Introduction

MR technique

Benign lesions

- Gastrointestinal stromal tumor

- Lipomas

Malignant lesions

- Adenocarcinoma

- Lymphoma

SMALL BOWEL

Domenico De Santis, Andrea Laghi

Introduction

MR technique

MR enteroclysis and MR enterography

Benign lesions

Crohn disease

Celiac disease

Adenoma

Malignant lesions

Gastrointestinal stromal tumors

Adenocarcinoma

Neuroendocrine tumors

Lymphoma

COLON

Marta Zerunian, Andrea Laghi

MR technique

Colorectal polyps and cancer

RECTUM (RECTAL CANCER)

Andrea Delli Pizzi, Regina G. H. Beets-Tan

Introduction

Rectal cancer management - general concepts

MR technique

Primary staging

T-staging

N-staging

Restaging after chemoradiotherapy

ANAL CANAL

Damiano Caruso, Andrea Laghi

MR technique and normal findings

Perianal fistulas

Squamous cell carcinoma of the anus

References

Kidney and urinary tract

KIDNEY

Maria Assunta Cova, Ilaria Fiorese,

Maria Chiara Ricciardi, Irene Campo

MR technique

Normal MR anatomy

Benign lesions

Cystic lesions

Focal cystic renal disease

Acquired multifocal cystic renal disease

Heritable multifocal cystic renal disease

Renal inflammatory lesions

Angiomyolipoma

Oncocytoma

Adenoma

Malignant lesions

Renal cell carcinoma

Cystic adenocarcinoma

Lymphoma

Transitional cell carcinoma

Metastases

MR IN PEDIATRICS - Kidney tumors

Angelo Lazzara, Marcello Napolitano,

Alessandro Campari, Maria Pia Bondioni

Introduction

Wilms tumor

URINARY TRACT

Maria Assunta Cova, Ilaria Fiorese,

Maria Chiara Ricciardi, Irene Campo

MR technique

Benign lesions

Fibroepithelial polyp

Pyonephrosis

Malignant lesions

Transitional cell carcinoma

MR IN PEDIATRICS - Urinary tract malformations

Angelo Lazzara, Marcello Napolitano,

Alessandro Campari, Maria Pia Bondioni

Embriology

Diagnosis

Classifications

Abnormalities of normal renal development

Aberrant migration and fusion anomalies

Abnormalities of collecting system development

BLADDER

Maria Assunta Cova, Ilaria Fiorese,

Maria Chiara Ricciardi, Irene Campo

MR technique

Benign lesions

Leiomyoma

Neurofibroma

Hemangioma

Solitary fibrous tumor

Malignant lesions

Transitional cell carcinoma

or urothelial carcinoma

Squamous cell carcinoma

Adenocarcinoma

Neuroendocrine tumors

Carcinoid

Leiomyosarcoma

Paraganglioma

Lymphoma

MR IN PEDIATRICS - Bladder tumors

Maria Assunta Cova, Ilaria Fiorese,

Maria Chiara Ricciardi, Irene Campo

Rhabdomyosarcoma

References

Morphological and functional MR urography

*Lidia Alcalá Mata, Juan A. Retamero,
M. Alvaro Berbís, Antonio Luna Alcalá*

Introduction
MR technique
 Patient preparation
 Morphological MR urography
 Functional MR urography
 Comprehensive MR urography protocol
Special populations
 Pediatric patients
 Pregnant patients
 Renal insufficiency
Clinical applications
 Urolithiasis
 Other causes of urinary tract obstruction
 Hematuria
 Congenital anomalies
 Infection
 Pre- and post-operative assessment
 of renal transplant
 Urothelial carcinoma
Pitfalls and artifacts
Future directions
 Quantitative MRI of regional renal function
 Artificial intelligence in MRI of kidneys
 and collecting systems

References

Adrenal glands

*Roberta Ambrosini, Filippo Vaccher,
Martina Bertuletti, Alberta Villanacci*

Introduction
MR technique
 MR normal anatomy
Benign lesions
 Hyperplasia
 Adenoma
 Myelolipoma
 Cysts
 Hemorrhage
 Ganglioneuroma
Malignant lesions
 Metastasis
 Adrenocortical carcinoma
 Pheocromocytoma
 Adrenal lymphoma

MR IN PEDIATRICS - Neuroblastoma and extra-adrenal neuroblastic tumors

*Alessandro Campari, Angelo Lazzara,
Marcello Napolitano, Maria Pia Bondioni*

References

Peritoneum

*Roberta Ambrosini, Alberta Villanacci,
Luca Bottoni, Francesca Castagnoli*

Introduction
Anatomy
MR technique
Benign lesions
 Mesenteric edema
 Peritonitis
 Sclerosing mesenteritis
 Peritoneal cysts
 Enteric duplication cysts and enteric cysts
 Mesothelial cysts
 Peritoneal inclusion cyst
 or benign cystic mesothelioma
 Mesenteric lymphangiomas
 Desmoid tumors
 Peritoneal adenomatoid tumor
Malignant lesions
 Peritoneal malignant mesothelioma
 Primary peritoneal papillary serous carcinoma
 Secondary tumors
 Pseudomyxoma peritonei
 Peritoneal spread of neoplastic diseases
 Peritoneal carcinomatosis

References

Retroperitoneum

*Giulia Zamboni, Alessandro Fighera,
Lorenzo Costa, Giancarlo Mansueto*

Introduction
MR technique
 Normal MR anatomy
Non-neoplastic lesions
 Retroperitoneal hematoma
 Amyloidosis
 Abscess
 Retroperitoneal fibrosis
 Erdheim-Chester disease
 Extramedullary hematopoiesis
 Lipomatosis
Malignant lesions
HEMATOLOGICAL MALIGNANCIES
 Lymphoma
 Extramedullary plasmacytoma
PRIMARY RETROPERITONEAL TUMORS
 Tumors of mesodermal mesenchymal origin
 Neurogenic tumors
 Extragenital germ cell tumors
 Others primary retroperitoneal cystic tumors

MR IN PEDIATRICS - Retroperitoneal tumors

*Alessandro Campari, Angelo Lazzara,
Marcello Napolitano, Maria Pia Bondioni*

References

Female genital system

*Maria Assunta Cova, Cristina Marrocchio,
Alessandro Marco Bozzato*

MR technique

- Patient preparation
- Magnets, coils, and patient positioning

ADNEXA

-
- Normal MR anatomy
 - Functional cysts
 - Follicular cysts
 - Corpus luteum cysts
 - Endometriosis
 - Epithelial tumors
 - Benign serous and mucinous tumors
 - Malignant serous and mucinous tumors
 - Endometrioid carcinoma
 - Clear cell carcinoma
 - Brenner tumor
 - Sex-cord stromal tumors
 - Granulosa cell tumor
 - Fibromas, fibrothecomas, thecomas
 - Sclerosing stromal tumors
 - Sertoli-Leydig cell tumors
 - Germ cell tumors
 - Mature teratoma
 - Immature teratoma
 - Dysgerminoma
 - Endodermal sinus tumor
 - Polycystic ovary syndrome
 - Ovarian torsion
 - Ectopic pregnancy
 - Inflammatory conditions
 - Tubo-ovarian abscess
 - Actinomycosis
 - Tuberculosis

UTERUS AND CERVIX

-
- Normal MR anatomy
 - Benign lesions
 - Congenital anomalies
 - Nabothian cysts
 - Adenomyosis
 - Polyps
 - Leiomyoma
 - Malignant lesions
 - Squamous cell carcinoma of the uterine cervix
 - Endometrial carcinoma
 - Sarcoma

URETHRA

-
- Normal MR anatomy
 - Benign lesions
 - Periurethral cysts
 - Diverticula
 - Benign solid lesions
 - Malignant lesions

VAGINA AND VULVA

VAGINA

-
- Normal MR anatomy
 - Benign lesions
 - Congenital anomalies
 - Cysts
 - Malignant lesions
 - Squamous cell carcinoma
 - Metastases

VULVA

Carcinoma

*References***Male genital system**

*Pietro Torricelli, Francesco Prampolini,
Lorenzo Reverberi*

PROSTATE

-
- Introduction
 - Anatomy
 - Blood supply
 - MR technique
 - Patient preparation
 - Type of coil
 - MR protocol
 - Prostate cancer
 - Diagnostic work-up
 - Magnetic resonance imaging
 - Spectroscopy*
 - Dynamic contrast-enhanced imaging*
 - PI-RADS scoring system*
 - Structured reporting*
 - Tumor staging
 - Therapy
 - State-of-the-art and future prospects
 - Benign lesions
 - Benign prostatic hyperplasia
 - Prostatitis

SEMINAL VESICLES AND VAS DEFERENS

-
- Anatomy
 - MR technique
 - Congenital anomalies
 - Agensis
 - Hypoplasia
 - Congenital cysts
 - Infections
 - Abscess
 - Amyloidosis
 - Primary tumors
 - Secondary tumors
 - Miscellaneous
 - Vas deferens anomalies

DIDYMUS AND EPIDIDYMIS

Introduction
MR technique
 Normal MR anatomy
Congenital anomalies
 Cryptorchidism
Hydrocele
Varicocele
Testicular torsion
Intratesticular masses
 Non-tumor intratesticular benign lesions
 Intratesticular benign tumors
 Adrenal rest tumor
 Malignant intratesticular tumors
 Intratesticular pseudotumor
Extratesticular masses
Inflammatory processes
 Orchitis
 Epididymitis
 Tuberculous orchiepididymitis
 Fournier's gangrene
Trauma
Testicular microlithiasis

PENIS AND URETHRA

Introduction
MR technique
 Normal MR anatomy
Benign lesions
 Congenital anomalies
 Urethral plate and canal malformations
 La Peyronie's disease
 Cowper syringocele
 Urethral spongiofibrosis
Vascular disorders
 Priapism
 Vascular impotence
Malignant lesions of the penis
 Squamous cell carcinoma of the penis
 Non-epithelial tumors
Trauma
Penile prosthesis

References

Abdominal MR angiography

Angelo Vanzulli, Pietro Gemma

Introduction
 Dark blood
 Bright blood
Thoracoabdominal aorta
 Introduction
 Indications
 MR technique
 Normal MR anatomy
 Basic sequences
Aortic pathology

Aneurysm
Dissection
Traumas
Renal arteries
 Introduction
 Indications
 MR technique
 Normal MR anatomy
 Nefrovascular hypertension
 Other renal arteries pathologies
Splanchnic and iliac vessels
 Indications
 MR technique
 Aneurysm
 Stenosis
 Thrombosis
 Dissection

References

Whole-body magnetic resonance imaging in oncology

Giuseppe Petralia, Paola Pricolo, Sarah Alessi, Fabio Zugni

Introduction
Technical notes
 Hardware
 Anatomical coverage
 Sequences
 Image post-processing
Clinical applications
 Multiple myeloma
 Lymphoma
 Prostate cancer
 Melanoma
 Breast
 Lung cancer
 Colorectal cancer
 Ovarian cancer
 Cancer screening

References

MR imaging to assess oncological treatment response

Andra Curcean, Joshua Shur, Mihaela Rata, Dow-Mu Koh

Introduction
Effects of antitumor treatment on cancers:
 implications for imaging
Conventional MR imaging
 to measure treatment response
 Size measurement criteria
 Modified RECIST criteria
 Changes in tumor morphology
 as response to treatment
Functional MR imaging techniques
 Diffusion-weighted MRI
 Dynamic contrast-enhanced MRI
 Intrinsic susceptibility MRI
 MR elastography

References