

Preface, ix

ABR study guide topics, xi

1 Production of net magnetization 1

- 1.1 Magnetic fields 1
- 1.2 Nuclear spin 2
- 1.3 Nuclear magnetic moments 4
- 1.4 Larmor precession 4
- 1.5 Net magnetization 6
- 1.6 Susceptibility and magnetic materials 8

2 Concepts of magnetic resonance 10

- 2.1 Radiofrequency excitation 10
- 2.2 Radiofrequency signal detection 12
- 2.3 Chemical shift 14

3 Relaxation 17

- 3.1 T1 relaxation and saturation 17
- 3.2 T2 relaxation, T2* relaxation and spin echoes 21

4 Principles of magnetic resonance imaging – 1 26

- 4.1 Gradient fields 26
- 4.2 Slice selection 28
- 4.3 Readout or frequency encoding 30
- 4.4 Phase encoding 33
- 4.5 Sequence looping 35

5 Principles of magnetic resonance imaging – 2 39

- 5.1 Frequency selective excitation 39
- 5.2 Composite pulses 44
- 5.3 Raw data and image data matrices 46
- 5.4 Signal-to-noise ratio and tradeoffs 47
- 5.5 Raw data and k-space 48
- 5.6 Reduced k-space techniques 51
- 5.7 Reordered k-space filling techniques 54
- 5.8 Other k-space filling techniques 56
- 5.9 Phased-array coils 58
- 5.10 Parallel acquisition methods 60

6 Pulse sequences 65

- 6.1 Spin echo sequences 67
- 6.2 Gradient echo sequences 70
- 6.3 Echo planar imaging sequences 75
- 6.4 Magnetization-prepared sequences 77

7 Measurement parameters and image contrast 86

- 7.1 Intrinsic parameters 87
- 7.2 Extrinsic parameters 89
- 7.3 Parameter tradeoffs 91

8 Signal suppression techniques 94

- 8.1 Spatial presaturation 94
- 8.2 Magnetization transfer suppression 96
- 8.3 Frequency-selective saturation 99
- 8.4 Nonsaturation methods 101

9 Artifacts 103

- 9.1 Motion artifacts 103
- 9.2 Sequence/Protocol-related artifacts 105
- 9.3 External artifacts 119

10 Motion artifact reduction techniques 126

- 10.1 Acquisition parameter modification 126
- 10.2 Triggering/Gating 127
- 10.3 Flow compensation 132
- 10.4 Radial-based motion compensation 134

11 Magnetic resonance angiography 135

- 11.1 Time-of-flight MRA 137
- 11.2 Phase contrast MRA 141
- 11.3 Maximum intensity projection 144
- 12 Advanced imaging applications 147
- 12.1 Diffusion 147

12.2 Perfusion 153

- 12.3 Functional brain imaging 156
- 12.4 Ultra-high field imaging 158
- 12.5 Noble gas imaging 159

13 Magnetic resonance spectroscopy 162

- **13.1 Additional concepts 162**
- **13.2 Localization techniques 167**
- **13.3 Spectral analysis and postprocessing 169**
- **13.4 Ultra-high field spectroscopy 173**

14 Instrumentation 177

- **14.1 Computer systems 177**
- **14.2 Magnet system 180**
- **14.3 Gradient system 182**
- **14.4 Radiofrequency system 184**
- **14.5 Data acquisition system 186**
- **14.6 Summary of system components 187**

15 Contrast agents 189

- **15.1 Intravenous agents 190**
- **15.2 Oral agents 195**

16 Safety 196

- **16.1 Base magnetic field 197**
- **16.2 Cryogenics 197**
- **16.3 Gradients 198**
- **16.4 RF power deposition 198**
- **16.5 Contrast media 199**

17 Clinical applications 200

- **17.1 General principles of clinical MR imaging 200**
- **17.2 Examination design considerations 202**
- **17.3 Protocol considerations for anatomical regions 203**
- **17.4 Recommendations for specific sequences and clinical situations 218**
- **References and suggested readings 222**

Index 225