Contents

Glossary x

1 **MR: What's the Attraction?** 1
- 1.1 It's not Rocket Science, but I Like It 1
- 1.2 A Brief History of Medical Imaging 1
- 1.3 How to Use this Book 5

Part I The Basic Stuff

2 **Early Daze: Your First Week in MR** 11
- 2.1 Introduction 11
- 2.2 Welcome to the MR Unit 11
- 2.3 Safety First 14
- 2.4 Safety Second: Additional Practical Guidelines 17
- 2.5 The Patient's Journey 21
- 2.6 MRI Radiographer's Blog . . . A Few Years On 23

3 **Seeing is Believing: Introduction to Image Contrast** 26
- 3.1 Introduction 26
- 3.2 Introduction to the T-Words 27
- 3.3 T_2-Weighted Images 27
- 3.4 FLAIR Images 28
- 3.5 T_1-Weighted Images 28
- 3.6 T_1w Images Post-Gd 29
- 3.7 STIR Images 30
- 3.8 PD-Weighted Images 32
- 3.9 Gradient-Echo Images 35
- 3.10 More About Contrast Agents 37
- 3.11 Angiographic Images 38
- 3.12 Diffusion-Weighted Images 39

4 **Lost in the Pulse Sequence Jungle?** 41
- 4.1 Introduction 41
- 4.2 Anatomy of a Pulse Sequence 41
- 4.3 Take Me for a Spin (Echo) 43
- 4.4 The Other Branch of the Tree: Gradient Echo 49
- 4.5 Echo Planar Imaging 54
- 4.6 The Pulse Sequence Traveller 54

5 **The Devil's in the Detail: Pixels, Matrices and Slices** 55
- 5.1 Introduction 55
- 5.2 From Analogue Signal to Digital Image 55
- 5.3 Matrices, Pixels and an Introduction to Resolution 58
- 5.4 Slices and Orientations 61
- 5.5 Displaying Images 61
- 5.6 What do the Pixels Represent? 63
- 5.7 From 2D to 3D 64

6 **What You Set is What You Get: Basic Image Optimization** 67
- 6.1 Introduction 67
- 6.2 Looking on the Bright Side: What are we Trying to Optimize? 67
- 6.3 Trading Places: Resolution, SNR and Scan Time 72
- 6.4 Ever the Optimist: Practical Steps to Optimization 76

7 **Improving Your Image: How to Avoid Artefacts** 81
- 7.1 Introduction 81
- 7.2 Keep Still Please! Motion Artefacts 81
- 7.3 Lose the Fat! 88
- 7.4 Digital Imaging Artefacts 92
- 7.5 Susceptibility and Metal Artefacts 96
- 7.6 Equipment Artefacts 98
- 7.7 What's Causing this Artefact? 101

8 **Spaced Out: Spatial Encoding** 102
- 8.1 Introduction 102
- 8.2 Anatomy of a Pulse Sequence 102
- 8.3 From Larmor to Fourier via Gradients 103
- 8.4 Something to get Excited About: The Image Slice 106
- 8.5 In-Plane Localization 110
- 8.6 Consequences of Fourier Imaging 117

Downloaded from https://www.cambridge.org/core. National Cheng Kung University, on 16 Sep 2019 at 02:12:56, subject to the Cambridge Core terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1017/9781107706958

8.7 Speeding It Up 120
8.8 3D FT 121

9 Getting in Tune: Resonance and Relaxation 124
9.1 Introduction 124
9.2 Spinning Nuclei 124
9.3 Measuring the Magnetic Moment 127
9.4 Relaxation Times 129
9.5 Creating Echoes 132
9.6 Relaxation Time Mechanisms 135
9.7 Gadolinium-based Contrast Agents 141

10 Let's Talk Technical: MR Equipment 144
10.1 Introduction 144
10.2 Magnets 144
10.3 Gradient Subsystem 149
10.4 Radiofrequency Transmit Subsystem 154
10.5 RF Receiver Subsystem 158
10.6 Computer Systems 162
10.7 Siting and Installation 163
10.8 Other Types of MRI Systems 164

11 Ghosts in the Machine: Quality Control 166
11.1 Introduction 166
11.2 The Quality Cycle 166
11.3 Signal Parameters 169
11.4 Geometric Parameters 173
11.5 Relaxation Parameters 177
11.6 Artefacts 178
11.7 Spectroscopic QA 179
11.8 Temporal Stability 179
11.9 Other Specialist QA 181

Part II The Specialist Stuff

12 Acronyms Anonymous I: Spin Echo 185
12.1 Introduction 185
12.2 Conventional Spin Echo 185
12.3 RARING to Go: Fast Spin-Echo Techniques 186
12.4 The Extended Family of TSE 191
12.5 Combining Gradient and Spin Echoes 200

13 Acronyms Anonymous II: Gradient Echo 207
13.1 Introduction 207
13.2 Image Formation in Gradient Echo 207
13.3 One Tree, Many Branches: FIDs, Echoes and Coherences 207
13.4 Ultra-Fast GE Imaging 218

14 The Parallel Universe: Parallel Imaging and Novel Acquisition Techniques 225
14.1 Introduction 225
14.2 Groundwork 225
14.3 Making SENSE: Parallel Imaging in Image Space 227
14.4 SMASH Hits: Parallel Imaging in k-Space 230
14.5 Undersampling by Simultaneous Multi-Slice Excitation 236
14.6 Image Quality in Parallel Imaging 237
14.7 k-t BLAST 240
14.8 Non-Cartesian Acquisition Schemes 242
14.9 Compressed Sensing 248

15 Go with the Flow: MR Angiography 251
15.1 Introduction 251
15.2 Effect of Flow in Conventional Imaging 251
15.3 Non-Contrast MR Angiography 255
15.4 Contrast-Enhanced MRA 263
15.5 Susceptibility-Weighted Imaging 267

16 A Heart to Heart Discussion: Cardiac MRI 269
16.1 Introduction 269
16.2 Patient Set-up 269
16.3 Morphological Imaging 272
16.4 Functional Imaging 273
16.5 Myocardial Perfusion 282
16.6 Myocardial Viability 284
16.7 Myocardial Tissue Characterization 286
16.8 Coronary Artery Imaging 286

17 It's Not Just Squiggles: In Vivo Spectroscopy 288
17.1 Introduction 288
17.2 Some Basic Chemistry 288
17.3 Single-Voxel Spectroscopy 291
17.4 Processing of Single-Voxel Spectra 295
17.5 Chemical Shift Imaging 297

18 To BOLDly Go: fMRI, Perfusion and Diffusion 303
18.1 Introduction 303
18.2 Diffusion Imaging 303

Downloaded from https://www.cambridge.org/core. National Cheng Kung University, on 16 Sep 2019 at 02:12:56, subject to the Cambridge Core terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1017/9781107706958

18.3 Perfusion Imaging 311
18.4 Dynamic Contrast Enhancement: Permeability Imaging 316
18.5 Brain Activation Mapping Using the BOLD Effect 319

19 Making it Count: Quantitative MRI 326
19.1 Introduction 326
19.2 Relaxation Times 326
19.3 Diffusion Parameters 334
19.4 Tissue Perfusion and Permeability 335
19.5 Fat Quantification 335
19.6 MR Elastography 338
19.7 Accuracy, Precision, and Diagnostic Confidence 341

20 But is it Safe? Bio-effects 345
20.1 Introduction 345
20.2 Radiofrequency Effects 345
20.3 Gradient Effects 347
20.4 Static Field Effects 351
20.5 MR Exposures and Pregnancy 352
20.6 Occupational Exposure 352
20.7 Contrast Agent Safety 354
20.8 So is MRI Safe? 356

21 Where Are We Going Now? 358
21.1 Introduction 358
21.2 7 Tesla Systems 358
21.3 Hyperpolarization 360
21.4 MR-PET 362
21.5 MR-LINAC 363

Appendix: maths revision 365
Index 369

Downloaded from https://www.cambridge.org/core. National Cheng Kung University, on 16 Sep 2019 at 02:12:56, subject to the Cambridge Core terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1017/9781107706958