
Contents

Part I Technology and Probe Design

Computed Tomography and Magnetic Resonance Imaging	3
1 Imaging Targets in Cancer	4
1.1 Introduction	4
1.2 Physiological Imaging Targets	5
1.3 Molecular Targets	7
1.4 Cellular Targets	8
1.5 Image-Guided Drug Delivery	8
2 Recent Technological Developments in X-ray Computed Tomography of Cancer	9
2.1 Basics of Multi-Slice Spiral Computed Tomography	9
2.2 Multi-Energy Computed Tomography	13
2.3 Preclinical Computed Tomography	14
2.4 Dedicated Imaging Systems and New Developments	15
2.5 Multimodality Imaging	16
3 Recent Technological Developments in Magnetic Resonance Imaging of Cancer	16
3.1 Magnetic Resonance Imaging: Introduction	16
3.2 MRI Signal Formation and Contrast	17
3.3 Magnetic Field Strength and Signal Sensitivity	21
3.4 Imaging Gradients, Signal Encoding, and Signal Reception Chain	21
3.5 MRI Pulse Sequences, Parametric Mapping	23
3.6 Contrast-Enhanced MRI	24
4 Imaging Biomarkers in Cancer	25
4.1 Imaging Biomarkers: X-ray Computed Tomography	25
4.2 Imaging Biomarkers: Magnetic Resonance Imaging	26
5 Magnetic Resonance Imaging Probes in Cancer	33
5.1 Introduction	33
5.2 Non-Targeted Probes	33
5.3 Targeted Probes	43
5.4 Responsive Probes	43
5.5 Reporter Genes	45

6	Future Perspectives	53
	References	53
	Single Photon Emission Computed Tomography Tracer	65
1	Introduction.	66
2	General Aspects for the Design of SPECT Tracers	69
3	Peptide-Receptor Radionuclide Imaging	73
	3.1 Somatostatin Analogs	74
	3.2 Bombesin Analogs	76
	3.3 Neurotensin Analogs.	79
	3.4 Other Peptides-Based Radiotracers	81
4	Antibodies and Antibody Fragments.	82
	4.1 Targeting Fibronectin Extra-Domain B: Antiangiogenic Antibody Fragment L19	84
5	Vitamin-Based Radiotracers	85
	5.1 Folic Acid Conjugates.	85
	5.2 Vitamin B12 Conjugates	87
	5.3 Other Vitamin Targeting Agents.	89
6	Intracellular Targets	90
	6.1 ^{99m}Tc -Carbohydrate Complexes	90
	6.2 Radiolabeled Nucleoside Analogs for Targeting Human Thymidine Kinase	91
	6.3 Radioiodinated Meta-Iodobenzylguanidine.	93
7	Optimization of SPECT Tracer Design and Potential Reasons for Failure	95
8	Summary and Conclusion	96
	References	97
	Non-peptidyl ^{18}F-Labelled PET Tracers as Radioindicators for the Noninvasive Detection of Cancer	107
1	Introduction.	108
2	^{18}F FDG for Imaging Glucose Metabolism	109
3	^{18}F -Labelled Amino Acids (AAs) for Imaging AA Transport and Protein Synthesis	111
	3.1 O-(2- ^{18}F Fluoroethyl)-l-tyrosine (^{18}F FET)	111
	3.2 6- ^{18}F Fluoro-3,4-dihydroxy-l-phenylalanine (^{18}F FDOPA).	113
4	^{18}F -Labelled Choline Derivatives for Imaging Membrane Lipid Synthesis	115
	4.1 ^{18}F Fluorocholine (Dimethyl- ^{18}F fluoromethyl-2- hydroxyethylammonium, ^{18}F FCH)	115
	4.2 ^{18}F Fluoroethylcholine (Dimethyl-2- ^{18}F fluoroethyl-2- hydroxyethylammonium, ^{18}F FECH)	117
5	^{18}F -Labelled Nucleoside Derivatives for Imaging Cell Proliferation	118

5.1	3'-Deoxy-3'-[¹⁸ F]fluoro-1-thymidine ([¹⁸ F]FLT)	118
5.2	1-(2'-Deoxy-2'-[¹⁸ F]fluoro-β-d-arabinofuranosyl)-5-methyluracil ([¹⁸ F]FMAU).	119
6	¹⁸ F-Labelled Nitroimidazole Derivatives for Imaging Tumour Hypoxia	120
6.1	[¹⁸ F]Fluoromisonidazole ([¹⁸ F]FMISO)	120
6.2	1-(5-Deoxy-5-[¹⁸ F]Fluoro-α-d-arabinofuranosyl)-2-nitroimidazole ([¹⁸ F]FAZA)	122
7	[¹⁸ F]FES for Imaging Estrogen Receptor Status.	122
8	[¹⁸ F]Fluoride for Imaging Bone Metabolism	124
9	Perspectives	124
	References	125
	Optical and Opto-Acoustic Imaging	133
1	Introduction.	134
2	Multi-Spectral Optoacoustic Tomography	135
2.1	Sensitivity of Biomarker Detection	139
2.2	Other Applications of Optoacoustic Imaging	142
3	FMT-XCT.	142
4	Overview of Performance Characteristics	145
5	Quantification	146
6	Optical Imaging Applications in Oncology	148
	References	149
	Multifunctional Magnetic Resonance Imaging Probes	151
1	The Need for Imaging and Contrast Agents in Oncology	152
2	Imaging Techniques and Contrast Agents	155
2.1	Magnetic Resonance Imaging of Cancer	155
2.2	Multifunctional Imaging Probes	159
3	Probing the Tumor Vasculature	161
3.1	Dynamic Contrast-Enhanced MRI	162
3.2	Macromolecular Dynamic Contrast-Enhanced MRI.	164
4	Molecular Imaging.	167
5	Combined Imaging and Therapy	175
6	Translations and Future Outlook	181
	References	183

Part II Preclinical Studies

	Preclinical SPECT and SPECT/CT	193
1	Introduction.	194

2	Part I: Considerations when Evaluating the Potential Role of SPECT/CT Imaging in a Preclinical Oncology Research Application	195
2.1	Choice and Implications of Various Small Animal Models of Cancer	195
2.2	Framing the Research Question in Imaging Terms	198
2.3	Available in vivo Imaging Modalities and Characteristics of Preclinical Oncology Applications Amenable to SPECT	198
2.4	SPECT Versus SPECT/CT.	199
3	Part II: Technical Considerations when Implementing SPECT/CT in Preclinical Oncology Research	200
3.1	Anesthesia and Animal Handling	200
3.2	Availability of Radiopharmaceuticals and Evaluation of Their Biodistribution Characteristics	201
3.3	Injection of the Radiopharmaceutical	203
3.4	Injection of CT Contrast Agent	203
3.5	Radiation Exposure.	203
4	Part III: State-of-the-Art Preclinical SPECT/CT Systems	205
4.1	SPECT/CT System Design	205
4.2	A Sampling of Available Small-Animal SPECT- and SPECT/CT Systems	207
4.3	Image Reconstruction Techniques and the Quest for Quantitative SPECT.	208
5	Part IV: Recent Examples of SPECT/CT as Applied in the Preclinical Oncology Setting	210
5.1	Characterizing Tumor Perfusion or Other Inherent Characteristics	210
5.2	Imaging the Targeting Abilities of Molecules in the Development of Potential Therapeutics and Molecular Imaging Agents	210
5.3	Imaging Cell Trafficking.	213
5.4	Imaging Gene Transfer and Expression.	213
5.5	Imaging Biodistributions and Evaluating Dosimetry—Chemotherapeutics and Combined Therapeutic/Imaging Agents	215
5.6	Imaging Other Pathologic Processes Associated with Cancer or Cancer Therapies	216
6	Conclusion	216
	References	216
	Optical Imaging	221
1	Non-Invasive Optical Imaging Techniques	222
2	Imaging Agents for Fluorescence Imaging	223
3	Reporter Systems for Bioluminescence Imaging	224

4	Biological Processes	224
4.1	Activity of Matrix Degrading Enzymes	224
4.2	Glucose Metabolism	225
4.3	Hypoxia	228
4.4	Proliferation	230
4.5	Angiogenesis	231
4.6	Cell Death	233
4.7	Blood Flow	235
5	Clinical Perspective	237
6	Outlook/A Critical View	240
	References	241
	Applications of Small Animal PET	247
1	Introduction	248
2	Small Animal PET	249
2.1	General Aspects	249
2.2	Small Animal PET	251
2.3	Small Animal CT and Small Animal PET	252
3	Conclusion	254
	References	254
	Preclinical Molecular Imaging Using PET and MRI	257
1	Introduction	258
2	Experimental Models of Cancer	259
3	Small Animal Molecular Imaging	261
4	Positron Emission Tomography	262
5	Magnetic Resonance Imaging and Spectroscopy	264
5.1	Contrast Agents	266
5.2	Dynamic Contrast-Enhanced MRI	268
5.3	Steady-State Susceptibility-Contrast MRI	269
5.4	Diffusion-Weighted MRI	270
5.5	Arterial Spin Labeling	274
5.6	Blood Oxygen Level Dependent MRI	274
6	Multimodality Imaging	275
7	Applications	276
7.1	Metabolism	276
7.2	Hypoxia	279
7.3	Reporter Gene	283
7.4	Angiogenesis	285
7.5	Apoptosis	288
7.6	Cellular Imaging	289
8	Animal Welfare and its Impact on Imaging	293
9	Summary and Outlook	296
	References	297

Part III Clinical Applications

Quantitative SPECT/CT	313
1 Introduction.	314
2 Technical Aspects	314
2.1 SPECT/CT Instrumentation	314
2.2 Registration of Multimodal Images	315
2.3 Attenuation Correction of SPECT.	316
2.4 Quantitatively Accurate SPECT/CT	318
3 Clinical Aspects.	326
4 Summary and Outlook	327
References	327
 Optical Imaging of Breast Tumors and of Gastrointestinal Cancer by Laser-Induced Fluorescence	331
1 Introduction.	332
2 Fluorescence Imaging of Breast Cancer	333
2.1 The PTB Fluorescence Mammograph	334
2.2 Examination Protocol	336
2.3 Results on Malignant and Benign Tumors	337
2.4 Advances of Permeability Sensitive Fluorescence Imaging with ICG	340
3 Cancer and Early Malignancies of the GI	343
3.1 Protoporphyrin IX as Tumor Marker.	343
3.2 Time-Gated Fluorescence Imaging	343
3.3 Clinical Studies	346
4 Outlook	347
References	348
 FDG PET and PET/CT	351
1 Introduction.	352
2 Clinical Applications of FDG PET and PET/CT in Oncology	353
2.1 Non-Small Cell Lung Cancer.	353
2.2 Oesophageal Cancer	355
2.3 Gastric Cancer	355
2.4 Colorectal Cancer.	356
2.5 Gastrointestinal Stromal Tumors.	356
2.6 Head and Neck Cancer	357
2.7 Melanoma	357
2.8 Lymphoma	358
2.9 Breast Cancer.	359
2.10 Ovarian Cancer	360
2.11 Sarcomas.	361
2.12 Pancreatic Cancer.	362

2.13	Thyroid Cancer	363
2.14	Cancer of Unknown Primary	364
2.15	Testicular Cancer	365
2.16	Prostate Cancer	366
3	Therapy Response Assessment with FDG PET and PET/CT	366
	References	367

Molecular Imaging in Oncology 371

1	Introduction to Non-FDG PET Tracers	372
2	Clinical Applications of ^{11}C -Choline	373
3	Clinical Applications of ^{18}F -DOPA	375
4	Clinical Applications of ^{11}C -Methionine	379
5	^{11}C -Acetate	382
6	Clinical Applications of ^{18}F -FLT	384
7	^{18}F -FET	385
8	^{18}F -Fluoride	386
9	Clinical Applications of PET Tracers for Hypoxia	387
10	Clinical Applications of PET Tracers for Angiogenesis	388
	References	389

Part IV Future Challenges

Future Challenges of Multimodality Imaging 403

1	Introduction	404
2	Technology and Probe Design	404
2.1	SPECT/CT	405
2.2	PET/CT	405
2.3	SPECT/MRI and PET/MRI	406
3	Tracers	407
4	Optical Imaging	411
5	Future and Conclusions	412
	References	413

Molecular Imaging in Oncology
Schober, O.; Riemann, B. (Eds.)
2013, XVI, 416 p., Hardcover
ISBN: 978-3-642-10852-5