Contents

Part I General

I.1 History and Principles of Hybrid Imaging ........................................ 3
James A. Patton

I.2 Normal Distribution, Variants, Pitfalls, and Artifacts ....................... 35
Ora Israel and Dominique Delbeke

Part II Clinical Applications in Oncology

II.1 Tumors of the Central Nervous System ........................................ 99
Aaron C. Jessop, Ronald C. Walker, and Dominique Delbeke

II.2 Hybrid Imaging of Head and Neck Malignancies ............................. 137
Arie Gordin, Marcelo Daitzchman, and Ora Israel

II.3 Lung Cancer .................................................................................. 171
Ronald C. Walker, Laurie B. Jones-Jackson, Aaron C. Jessop,
and Dominique Delbeke

II.4 Breast Cancer ............................................................................... 217
Simona Ben-Haim and Vineet Prakash

II.5 Colorectal Cancer ......................................................................... 261
Dominique Delbeke and Ronald C. Walker

II.6 18F-FDG PET/CT in Tumors of the Gastrointestinal Tract: Esophageal
and Gastric Cancer and Gastrointestinal Stromal Tumors (GIST) .......... 293
Rachel Bar-Shalom and Ludmila Guralnik

II.7 Hepatobiliary and Pancreatic Malignancies ................................... 331
Dominique Delbeke and Ronald C. Walker

II.8 Gynecological Tumors ................................................................. 383
Farrokh Dehdashti and Barry A. Siegel
II.9 Hybrid Imaging in Malignancies of the Urinary Tract, Prostate, and Testicular Cancers ........................................... 409  
Martine Klein and Marina Orevi

II.10 Thyroid Cancer ................................................................... 445  
Heather A. Jacene, Sibyll Goetze, and Richard L. Wahl

II.11 Endocrine Tumors .............................................................. 475  
Yodphat Krausz

II.12 Lymphoma ......................................................................... 513  
Michal Weiler-Sagie and Ora Israel

II.13 Melanoma ........................................................................... 555  
Ronald C. Walker, Laurie B. Jones-Jackson, Aaron C. Jessop, and Dominique Delbeke

II.14 Malignancy of the Bone: Primary Tumors, Lymphoma, and Skeletal Metastases .......................................... 583  
Einat Even-Sapir, Gideon Flusser, and Arye Blachar

II.15 Pediatric Applications for PET/CT and SPECT/CT .............. 621  
Helen R. Nadel and Angela T. Byrne

Part III Other Clinical Applications

III.1 Cardiac Hybrid Imaging (PET/CT and SPECT/CT): Assessment of CAD ............................................ 659  
Gabriel Vorobiof, Zohar Keidar, Sharmila Dorbala, and Marcelo F. Di Carli

III.2 Hybrid Imaging of Benign Skeletal Diseases ......................... 683  
Einat Even-Sapir, Hedva Lerman, Gideon Flusser, and Arye Blachar

III.3 Infectious and Inflammatory Diseases ............................... 711  
Christopher J. Palestro, Zohar Keidar, and Charito Love

Subject Index .............................................................................. 747
# Expanded Contents

## Part I  General

### I.1  History and Principles of Hybrid Imaging

- Introduction .......................... 3
- Single Photon Emission Computed Tomography .......................... 3
- Data Acquisition .......................... 4
- SPECT Image Formation .................................. 6
- Positron Emission Tomography . . . . . . . . . . . . . . . . 13
- PET Detectors .................................. 14
- 2D Versus 3D Imaging ......................... 16
- Data Acquisition and Image Reconstruction .......................... 16
- Time-of-Flight PET .................................. 18
- Quantitative Techniques .......................... 18
- X-Ray Computed Tomography .................... 21
- SPECT/CT and PET/CT .......................... 24
- Clinical SPECT/CT Systems .................... 26
- Clinical PET/CT Systems ....................... 27
- Contrast Agents ............................. 27
- Beam-Hardening Artifacts ...................... 28
- Physiological Motion .......................... 28
- Radiation Dosimetry Considerations .................. 28
- Quality Assurance .......................... 29
- Conclusions .................................. 31
- References .................................. 32

### I.2  Normal Distribution, Variants, Pitfalls, and Artifacts

- PET/CT Imaging with $^{18}$F-Fluorodeoxyglucose .......................... 35
- Normal $^{18}$F-FDG Distribution and Physiologic Variants .......................... 35
- Pitfalls and Artifacts on $^{18}$F-FDG Imaging .......................... 37
- Benign Processes Accumulating $^{18}$F-FDG .......................... 38
- Treatment-Related Processes Accumulating $^{18}$F-FDG ...................... 38
- Summary .................................. 39
- Physiologic Distribution of Other PET Tracers .......................... 40
- $^{18}$F-Fluoride .................................. 40
- $^{18}$F-Fluorothymidine .......................... 40
- $^{11}$C-Choline .................................. 41
- Fluorocholine $^{11}$C-Acetate .......................... 41
11C-Methionine..............................................42
18F-Fluorodopamine.........................................42
18F-Fluoromisonidazole.....................................42
68Ga-Somatostatin Receptors................................43
Physiologic Distribution of SPECT/CT Imaging Tracers..............................................43
131I- and 123I-Iodine (131I and 123I)...................43
131I- and 133I-MIBG..........................................44
111In-DTPA-Octreotide.....................................44
99mTc-Sestamibi.............................................45
111In- and 99mTc-HMPAO-Leucocytes (WBC)...............45
67Ga-Citrate..................................................46
111In-Prostascint............................................46

Case Presentations............................................48
1.2.1 Normal 18F-FDG Distribution (DICOM Images on DVD)..............................................48
1.2.2 Physiologic 18F-FDG Uptake in aSymmetric Vocal Cord..............................................56
1.2.3 Rebound Thymic Hyperplasia.............................58
1.2.4 Recurrent Hodgkin’s Disease and Abdominal Wall Muscular Uptake in a Patient with Nausea and Vomiting..........................................................61
1.2.5 Diffuse Muscular Uptake in a Non-fasting Patient.......................................................63
1.2.6 Pericarditis and Crossed Ectopic Kidney..........................66
1.2.7 18F-FDG Uptake in Menstruating Uterus and Right Ovary at Mid-Menstrual Cycle.............70
1.2.8 Hodgkin’s Disease and Lactating Breast..........................................................73
1.2.9 Brown Adipose Tissue Above and Below the Diaphragm.......................................75
1.2.10 Normal Distribution of 18F-FLT in a Patient with Menetrier’s Disease..............................80
1.2.11 131I-Iodine: Remnant Left Lobe Thyroid Tissue on Post-Ablation Study........................82
1.2.12 131I-Iodine: Physiological Uterine Uptake During Menstruation on Post-Ablation Study........84
1.2.13 123I MIBG: Right Adrenal Pheochromocytoma and Dilated Right Renal Pelvis..................87
1.2.14 99mTc-sestamibi: Left Parathyroid Adenoma, Atrophy of Right Submandibular Gland and Slightly Enlarged Right Lobe of the Thyroid.................................................91

References........................................................................94

Part II Clinical Applications in Oncology.............................................97

II.1 Tumors of the Central Nervous System.............................................99
Introduction......................................................................99
Physiologic Distribution of 18F-FDG in the CNS.............................................100
Initial Evaluation and Staging of Primary Cerebral Tumors.............................101
Evaluation of Treated Primary Cerebral Tumors..............................................102
Evaluation of Cerebral Metastases......................................................102
Evaluation of Meningiomas................................................................103
### Summary

Guidelines and Recommendations for the use of $^{18}$F-FDG PET and PET/CT ................................................... 104

### Case Presentations

- **II.1.1** Low-grade Glioma (Oligodendroglioma, WHO Grade II) .......................................................... 105
- **II.1.2** Recurrent Glioma with Transformation from Low-Grade to High-Grade ............................................. 108
- **II.1.3** Primary Lymphoma of CNS ................................................. 110
- **II.1.4** Toxoplasmosis (DICOM Images on DVD) .......................................... 113
- **II.1.5** Stage IV Non-small Cell Lung Cancer with Cerebral Metastases and Poor FDG Uptake within the Brain due to Hyperglycemia .................................................. 117
- **II.1.6** Right Frontal Cerebral Arteriovenous Malformation .................. 119
- **II.1.7** Recurrent Glioblastoma Multiforme with Diminished Uptake in the Right Temporal Region due to Post-therapy Changes and Crossed Cerebellar Diaschisis (DICOM Images on DVD) .... 122
- **II.1.8** Meningioma ..................................................... 126
- **II.1.9** Recurrent Low-grade Glioma Evaluated with $^{11}$C-methionine . . 131

### References .......................................................... 134

### II.2 Hybrid Imaging of Head and Neck Malignancies

- **II.2.1** Neck Metastasis of Unknown Origin ......................... 144
- **II.2.2** Cancer of the Larynx with Suspected Lung Metastases ........ 146
- **II.2.3** Recurrent Cancer of the Nasopharynx: PET/CT Guided Biopsy and Diagnosis (DICOM Images on DVD) .......... 149
- **II.2.4** Second Primary Cancer of the Esophagus in Patient with Suspected Recurrence of Laryngeal Tumor ............ 153
- **II.2.5** Recurrent Cancer of the Larynx: PET/CT Guided Biopsy and Diagnosis ................................................. 156
- **II.2.6** Assessment of the Post-Irradiated Edematous Larynx with PET/CT .................................................. 158
- **II.2.7** Cancer of the Base of the Tongue with Normal Size Cervical Metastasis .................................................. 160
- **II.2.8** Multiple Regional and Distant Metastases in Patient with Advanced Laryngeal Cancer .................................. 162
- **II.2.9** Benign FDG-avid Lesion: Warthin’s Tumor of Parotid Gland .... 166

### References .......................................................... 168
II.3 Lung Cancer .................................................... 171
  Introduction ................................................. 171
  Indeterminate Pulmonary Nodules ............................ 171
    Non-surgical Evaluation of Pulmonary Nodules .............. 172
    18F-FDG PET/CT for Evaluation of Pulmonary Nodules ....... 173
    Guidelines for Evaluation of Indeterminate Nodules ....... 174
  Non-Small-Cell Lung Carcinoma (NSCLC) ..................... 175
    TNM Staging of NSCLC ..................................... 175
    18F-FDG Imaging for Staging of NSCLC at Presentation: 
      Comparison to CT ........................................ 176
      Detection of Extra-Thoracic Metastases .................. 177
    Impact of 18F-FDG Imaging on Management of NSCLC at Presentation 178
    18F-FDG Imaging for Monitoring Therapy of NSCLC .......... 178
    Detection of Recurrence and Restaging with 18F-FDG PET or PET/CT 179
    Summary .................................................. 179
  Small-Cell Lung Carcinoma (SCLC) ........................... 180
    18F-FDG PET and PET/CT for Staging, Restaging, and Assessment 
      of Treatment Response of SCLC .......................... 180
    Summary .................................................. 181
  Malignant Pleural Mesothelioma ............................... 181
    Introduction ............................................... 181
    18F-FDG Imaging of MPM .................................... 183
    Assessment of Metabolic Response to Treatment of MPM .... 184
    Summary .................................................. 184
  Guidelines and Recommendations for the Use of F-FDG PET and PET/CT 184

Case Presentations .............................................. 186
  II.3.1 Solitary Pulmonary Nodule with Moderate 18F-FDG Uptake: 
    Solitary Metastasis ....................................... 186
  II.3.2 Solitary Pulmonary Mass with Moderate 18F-FDG Uptake: 
    Granuloma ................................................ 188
  II.3.3 Solitary Pulmonary Nodule with Intense 18F-FDG Uptake: 
    Primary Lung Cancer ...................................... 190
  II.3.4 Multi-focal Primary Lung Cancer: Bronchoalveolar Cell 
    Carcinoma ................................................ 192
  II.3.5 Restaging of Recurrent NSCLC: Recurrent TNM Stage IIA .... 194
  II.3.6 Pre-operative Staging of NSCLC with 18F-FDG PET/CT: 
    Stage IIA ............................................... 197
  II.3.7 Pre-operative Staging of NSCLC with 18F-FDG PET/CT: 
    Stage IIIB and Adenomatous Polyp of the Transverse Colon ... 199
  II.3.8 Pre-operative Staging of NSCLC with 18F-FDG PET/CT: 
    Stage IV and Radiation Pneumonitis (DICOM Images on DVD) ... 201
  II.3.9 Pre-operative Staging of SCLC with 18F-FDG PET/CT: 
    Limited-Stage Disease .................................... 205
  II.3.10 Pre-treatment Staging of Malignant Pleural Mesothelioma with 
    18F-FDG PET/CT (DICOM Images on DVD) .................. 207
  II.3.11 Use of 18F-FDG PET/CT for Radiation Treatment Planning of 
    NSCLC .................................................. 211

References ..................................................... 213
II.4 Breast Cancer

Introduction ................................................................. 217

$^{18}$F-FDG PET and PET/CT for the Detection and Staging of Breast Cancer .................................................. 217

$^{18}$F-FDG PET and PET/CT for the Detection of Metastatic Breast Cancer .......................................................... 218

$^{18}$F-FDG PET and PET/CT for the Detection and Staging of Recurrent Breast Cancer ..................................... 219

$^{18}$F-FDG Imaging to Monitor Therapy of Breast Cancer ....................................................................................... 219

$^{18}$F-FDG PET/CT for Radiation Therapy Planning in Breast Cancer ............................................................... 220

Summary ................................................................................. 220

Guidelines and Recommendations for the Use of $^{18}$F-FDG PET and PET/CT ................................................. 221

Case Presentations ............................................................... 222

II.4.1 Unsuspected Breast Primary Cancer .................................................. 223

II.4.2 Metastatic Breast Cancer to Omentum, Peritoneum, and Ovaries with Partial Response to Treatment .......... 226

II.4.3 Metastatic Breast Cancer to Liver, T8 Vertebral Body, Right Femur, and Acetabulum ................................ 232

II.4.4 Recurrent Left Breast Cancer with Regional Metastases to Left Chest Wall and Synchronous Right Thyroid Papillary Cancer (DICOM Images on DVD) .................................................. 236

II.4.5 Solitary Hepatic Metastasis, Right Chest Wall Breast Cancer Recurrence, and Right Apical Lung Metastasis Causing Brachial Plexopathy .................................................. 242

II.4.6 Metastatic Breast Cancer to Bones, Left Lung, and Pleura: Good Response to Therapy in Left Lung and Pleura; Partial Response to Therapy in Bones (DICOM Images on DVD) .................. 246

References ........................................................................... 248

II.5 Colorectal Cancer ........................................................................ 261

Introduction .......................................................................... 261

$^{18}$F-FDG PET and PET/CT for Screening and Diagnosis of Colorectal Carcinoma ................................................. 261

$^{18}$F-FDG PET and PET/CT in the Initial Staging of Colorectal Carcinoma ......................................................... 262

$^{18}$F-FDG PET and PET/CT for Assessment of Recurrent Colorectal Carcinoma .................................................. 262

Detection and Restaging of Recurrence .................................................. 262

Impact on Management and Cost Analysis in Patients with Recurrent Disease .................................................. 263

$^{18}$F-FDG Imaging for Monitoring Therapy Response of Colorectal Carcinoma .................................................. 265

Systemic Chemotherapy .................................................................. 265

Radiation Therapy ........................................................................ 265

Regional Therapy to the Liver ....................................................... 266

Summary ........................................................................... 266

Guidelines and Recommendations for the Use of $^{18}$F-FDG PET and PET/CT .................................................. 266
Case Presentations .......................................................... 268
   II.5.1 Incidental Primary Transverse Colon Carcinoma in a Patient
      with Lung Cancer and Malignant Fibrohistiocytoma (DICOM
      Images on DVD) ..................................................... 268
   II.5.2 Primary Metastatic Rectal Carcinoma .......................................................... 274
   II.5.3 Colon Cancer with Hepatic Metastases .......................................................... 279
   II.5.4 Local Recurrence and Metastatic Retroperitoneal Lymph Nodes
      (DICOM Images on DVD) ............................................... 281
   II.5.5 Colon Cancer with Pulmonary Metastases ..................................................... 286
   II.5.6 Mucinous Adenocarcinoma of the Colon ..................................................... 288
References .................................................................................. 290

II.6 18F-FDG PET/CT in Tumors of the Gastrointestinal Tract:
      Esophageal and Gastric Cancer and Gastrointestinal Stromal
Tumors (GIST) .............................................................................. 293
   18F-FDG Imaging in Esophageal Cancer .......................................................... 293
      Introduction .................................................................................. 293
      18F-FDG Imaging for Staging of Esophageal Cancer ...................................... 294
      18F-FDG Imaging for Monitoring Response to Treatment
      of Esophageal Cancer ......................................................................... 295
      18F-FDG Imaging for Diagnosis of Recurrent Esophageal Cancer .................. 296
   18F-FDG Imaging in Gastric Cancer .......................................................... 296
      Introduction .................................................................................. 296
      18F-FDG Imaging for Diagnosis and Staging of Gastric Cancer ...................... 297
      18F-FDG Imaging for Monitoring Response to Treatment of Gastric
      Cancer ....................................................................................... 298
      18F-FDG Imaging for Diagnosis of Recurrent Gastric Cancer ......................... 298
      18F-FDG Imaging in Gastrointestinal Stromal Tumors ...................................... 299
      Introduction .................................................................................. 299
      18F-FDG Imaging at Initial Diagnosis of GIST ................................................. 300
      18F-FDG Imaging for Monitoring Response to Treatment of GIST ............... 300
Guidelines and Recommendations for the Use of 18F-FDG PET and
PET/CT in Esophageal Cancer ..................................................... 301
Case Presentations .......................................................... 302
   II.6.1 Distal Esophageal Cancer at Staging: Loco-regional
      Metastatic Adenopathy at the Level of the Gastro-hepatic
      Ligament and Distant Non-regional Metastasis in Left
      Pre-tracheal Lymph Node (DICOM Images on DVD) .................................. 302
   II.6.2 Increase Focal 18F-FDG Gastric Uptake at Site of Upper
      Anastomosis, Most Probably due to Physiologic Uptake
      or a Mild Inflammatory Process ..................................................... 307
   II.6.3 Primary Gastric Cancer with no Evidence of Metastases;
      Degenerative Changes in Cervical Spine (DICOM Images
      on DVD) .................................................................................. 309
   II.6.4 Adenocarcinoma of Gastro-esophageal Junction with Nodal
      Metastasis in Porta-hepatic Region and Inflammatory Lung
      Infiltrate .................................................................................. 315
II.6.5 Para-rectal GIST with no Evidence for Metastases: Complete Metabolic Response to treatment with Gleevec on $^{18}\text{F-FDG-PET}$ and Partial Response with Residual Para-rectal Mass on CT 319

II.6.6 Recurrent GIST within Multiple Omental and Peritoneal Metastases 322

References 327

II.7 Hepatobiliary and Pancreatic Malignancies 331

Hepatobiliary Neoplasms 331
Pancreatic Neoplasms 332
Imaging of Hepatobiliary and Pancreatic Neoplasms 332
Hepatic Metastases 334
$^{18}\text{F-FDG PET/CT Imaging of Hepatic Metastases}$ 334
Hepatocellular Carcinoma 334
$^{18}\text{F-FDG PET/CT for Diagnosis and Staging of HCC}$ 335
$^{11}\text{C-Acetate Imaging of HCC}$ 335
Cholangiocarcinoma 336
$^{18}\text{F-FDG PET/CT for Diagnosis and Staging of Cholangiocarcinoma}$ 336
Gallbladder Carcinoma 337
$^{18}\text{F-FDG PET/CT for Diagnosis and Staging of Gallbladder Carcinoma}$ 337
$^{18}\text{F-FDG PET/CT Monitoring Therapy of Hepatic Tumors}$ 337
Pancreatic Cancer 338
$^{18}\text{F-FDG PET/CT for Preoperative Diagnosis of Pancreatic Carcinoma}$ 339
$^{18}\text{F-FDG PET/CT for Staging of Pancreatic Carcinoma}$ 340
$^{18}\text{F-FDG PET/CT in the Post-therapy Setting}$ 340
Impact of $^{18}\text{F-FDG PET/CT on Management of Patients with Pancreatic Carcinoma}$ 340
Limitations of $^{18}\text{F-FDG Imaging}$ 341
Summary 341
Guidelines and Recommendations for the Use of $^{18}\text{F-FDG PET and PET/CT}$ 342

Case Presentations 343

II.7.1 Hepatocellular Carcinoma (DICOM Images on DVD) 343
II.7.2 Cholangiocarcinoma 350
II.7.3 Gallbladder Carcinoma 355
II.7.4 Pancreatic Carcinoma (DICOM Images on DVD) 360
II.7.5 Klatskin’s Tumor and Acute Pancreatitis 366
II.7.6 Cavernous Hemangioma 371
II.7.7 Focal Nodular Hyperplasia 373
II.7.8 Monitoring Therapy of Hepatic Metastases Treated with $^{90}\text{Y-microspheres}$ 377

References 379

II.8 Gynecological Tumors 383

Introduction 383
Cervical Cancer 383
$^{18}\text{F-FDG PET/CT in Staging Cervical Cancer}$ 383
$^{18}\text{F-FDG PET/CT in Directing Therapy in Cervical Cancer}$ 384
### Case Presentations

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>II.9.1</td>
<td>Renal Cell Carcinoma with Left Pulmonary Metastasis</td>
</tr>
<tr>
<td>II.9.2</td>
<td>RCC with Recurrent Skeletal Metastasis (DICOM Images on DVD)</td>
</tr>
<tr>
<td>II.9.3</td>
<td>Muscle Invasive TCC of Bladder with Single Nodal Metastasis</td>
</tr>
<tr>
<td>II.9.4</td>
<td>Muscle Invasive TCC of Bladder with Bilateral Pelvic Lymph Nodes Metastases (DICOM Images on DVD)</td>
</tr>
<tr>
<td>II.9.5</td>
<td>Primary Prostate Cancer with Right Obturator Nodal Metastasis</td>
</tr>
<tr>
<td>II.9.6</td>
<td>Local Recurrence of Prostate Cancer and Paget’s Disease of Right Iliac Bone</td>
</tr>
<tr>
<td>II.9.7</td>
<td>Metastatic Seminoma Achieving a Complete Remission</td>
</tr>
</tbody>
</table>

**References** 441

### II.10 Thyroid Cancer

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>445</td>
</tr>
<tr>
<td>Differentiated Thyroid Cancer</td>
<td>446</td>
</tr>
<tr>
<td>Radioiodine Whole-Body Scintigraphy with SPECT/CT</td>
<td>446</td>
</tr>
<tr>
<td>$^{18}$F-FDG PET/CT</td>
<td>446</td>
</tr>
<tr>
<td>Hürthle Cell Carcinoma</td>
<td>447</td>
</tr>
<tr>
<td>Anaplastic Thyroid Cancer</td>
<td>448</td>
</tr>
<tr>
<td>Medullary Thyroid Cancer</td>
<td>448</td>
</tr>
<tr>
<td>Thyroid Incidentalomas on $^{18}$F-FDG PET/CT</td>
<td>449</td>
</tr>
<tr>
<td>Guidelines and Recommendations for the Use of $^{18}$F-FDG PET and PET/CT</td>
<td>449</td>
</tr>
</tbody>
</table>

**Case Presentations** 450

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>II.10.1</td>
<td>Recurrent Papillary Thyroid Carcinoma in Right Upper Paratracheal Lymph Nodes (DICOM Images on DVD)</td>
</tr>
<tr>
<td>II.10.2</td>
<td>Metastatic Papillary Thyroid Cancer, Bilateral Central and Right lateral Neck Lymph Nodes (DICOM Images on DVD)</td>
</tr>
<tr>
<td>II.10.3</td>
<td>Persistent, Iodine-avid Hürthle Cell Carcinoma in Left Iliac/Sacral Metastasis</td>
</tr>
<tr>
<td>II.10.4</td>
<td>Anaplastic Thyroid Carcinoma in the Thyroid Gland and Possible Metastasis in a Left Parotid Lymph Node</td>
</tr>
<tr>
<td>II.10.5</td>
<td>Medullary Thyroid Cancer with Metastatic Left Neck Lymphadenopathy, Active and Treated Skeletal Metastases, and Treated Hepatic Metastases</td>
</tr>
<tr>
<td>II.10.6</td>
<td>Recurrent Medullary Thyroid Cancer with Right Paratracheal and Left Level II Lymph Nodes, Skeletal Metastases, and Physiologic Scalene Muscle $^{18}$F-FDG Uptake</td>
</tr>
<tr>
<td>II.10.7</td>
<td>Recurrent Melanoma of the Right Nasal Cavity Mucosa and Papillary Thyroid Carcinoma</td>
</tr>
</tbody>
</table>

**References** 471

### II.11 Endocrine Tumors

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>475</td>
</tr>
<tr>
<td>Imaging Protocols</td>
<td>476</td>
</tr>
<tr>
<td>SPECT/CT and PET/CT Tracers for Imaging of NE Tumors</td>
<td>476</td>
</tr>
</tbody>
</table>
SPECT/CT and PET/CT of GEP Tumors ......................... 478
SPECT/CT and PET/CT of Neural Crest Tumors ............... 479
SPECT/CT of Parathyroid Adenoma .......................... 481
Summary .................................................................. 482

Case Presentations ............................................... 483
II.11.1 Well-differentiated Small Intestine Neuroendocrine Tumor with Mesenteric Metastasis (DICOM Images on DVD) ........................................ 483
II.11.2 VIPoma in Body of the Pancreas ....................... 488
II.11.3 Pancreatic Neuroendocrine Carcinoma with Disseminated Hepatic and Skeletal Metastases Expressing High Density of Somatostatin Receptors 491
II.11.4 Suspected Recurrence of Pheochromocytoma in Left Adrenal Bed ................................................ 494
II.11.5 123I-MIBG Avid Pheochromocytoma Metastatic to Lungs and Liver ................................................. 498
II.11.6 Left Upper Parathyroid Adenoma in Posterior Location between the Trachea and Esophagus ............... 503
II.11.7 Ectopic Parathyroid Adenoma in Mid-anterior Lower Neck ......................................................... 506
II.11.8 68Ga-DOTATOC-avid Neuroendocrine Tumor in Tail of Pancreas .................................................... 508

References ............................................................ 509

II.12 Lymphoma .......................................................... 513
Introduction .......................................................... 513
Non-Hodgkin’s Lymphoma ......................................... 513
Hodgkin's Disease ................................................... 515
18F-FDG Imaging for Diagnosis of NHL and HD ............ 516
18F-FDG Imaging at Initial Staging of Lymphoma .......... 516
18F-FDG Avidity of HD and NHL ................................ 516
Comparative Performance of 18F-FDG Imaging and CT .... 516
Diagnosis of Bone Marrow Involvement ....................... 517
18F-FDG Staging Criteria in HD and NHL .................... 517
18F-FDG Imaging for Monitoring Therapy Response in Lymphoma ....................................................... 517
Definition of Response .............................................. 517
Timing of 18F-FDG Imaging in Assessing Response to Treatment in Lymphoma ........................................ 518
During and End-of-Treatment 18F-FDG Imaging in Lymphoma ......................................................... 518
18F-FDG Imaging of a Residual Mass .......................... 519
Pitfalls in Interpretation ............................................ 519
18F-FDG Imaging for Diagnosis and Restaging of Lymphoma Recurrence ........................................... 520
Summary ............................................................... 520
Guidelines and Recommendations for the Use of 18F-FDG-PET and PET/CT ........................................... 521
Case Presentations ............................................... 523
II.12.1 NHL-DLCL of the Spleen (with local invasion to LN in splenic hilum and to tail of pancreas) (DICOM Images on DVD) ........................................ 523
II.12.2 NHL-DLCL Stage IV: Good Response to Treatment
II.12.3 HD, Nodular Sclerosis Type Stage III: Good Early Response at Mid-treatment (DICOM Images on DVD)
II.12.4 Recurrent Small Lymphocytic NHL and Infection in Right Groin
II.12.5 HD, Refractory to First Line Chemotherapy: CR after Salvage Therapy and AHCT
II.12.6 Recurrent Follicular Grade II NHL and Gastritis
II.12.7 Early Relapse of HD
II.12.8 Recurrent Follicular Grade II NHL
II.12.9 HD in Complete Remission: Transient Foci of Increased 18F-FDG Activity due to Inflammation

References

II.13 Melanoma

Introduction
Cutaneous Melanoma
Diagnosis
Staging
Detection of Recurrence and Restaging with 18F-FDG PET and PET/CT
Choroidal Melanoma
Summary
Guidelines and Recommendations for the Use of 18F-FDG PET and PET/CT

Case Presentations

II.13.1 Metastatic Melanoma with Cerebral Metastases Seen on CT Only
II.13.2 Metastatic Melanoma s/p Regional Lymph Node Dissection
II.13.3 Metastatic Melanoma to the Right Ventricle and Pulmonary Emboli (DICOM Images on DVD)
II.13.4 Choroidal Melanoma
II.13.5 No Evidence of Recurrence in a Patient Treated with Vaccine
II.13.6 Widely Metastatic Melanoma including the Mesentery (DICOM Images on DVD)
II.13.7 SPECT/CT of a Cervical Sentinel Lymph Node

References

II.14 Malignancy of the Bone: Primary Tumors, Lymphoma, and Skeletal Metastases

Skeletal Metastases, Bone Lymphoma, and Multiple Myeloma
18F-FDG PET/CT for Diagnosis of Malignant Skeletal Lesions
18F-FDG PET/CT for Monitoring Response to Therapy
Advantages of 18F-FDG PET/CT in Malignant Skeletal Involvement
Summary
Primary Skeletal Malignancies ................................................................. 585

18F-FDG PET/CT for Diagnosis of Primary Skeletal Tumors ................. 585
18F-FDG PET/CT for Staging Primary Skeletal Tumors ....................... 585
18F-FDG PET/CT for Monitoring Response to Therapy ....................... 586

Summary ............................................................................................... 586

Case Presentations ............................................................................... 587

II.14.1 Lung Cancer with Direct Extension to Bone and Distant Skeletal Metastases (DICOM Images on DVD) .................. 587
II.14.2 Marrow-based and Cortical Skeletal Metastases before and with Partial Response after Treatment, and Hepatic Metastases .... 592
II.14.3 Lung Cancer with Extensive Skeletal Metastatic Spread and Invasion of the Epidural Space at T11 ................................. 598
II.14.4 Lymphoma with Skeletal Involvement and Suspected Involvement of the Left S1 Neural Foramen, in addition to Nodal Pleural and Muscular Disease ....................................................... 600
II.14.5 Primary Lymphoma of the Bone ............................................... 604
II.14.6 Multiple Myeloma with Active Disease in Rib and Post-radiotherapy Inactive Disease in Vertebra ................................. 610
II.14.7 Ewing Sarcoma of the Proximal Femur with Muscular Involvement, Pulmonary Metastases, and Suspected Additional Distant Sites of Disease in Bone and Lymph Nodes (DICOM Images on DVD) ................................................................. 612

References ........................................................................................... 618

II.15 Pediatric Applications for PET/CT and SPECT/CT .................... 621

Introduction .......................................................................................... 621
Neuroblastoma ..................................................................................... 621
Sarcoma .................................................................................................. 622
Lymphoma ............................................................................................ 623
Considerations on Radiation Exposure from PET/CT ......................... 624
PET/CT Procedure and Preparation of the Pediatric Patient ............. 625
SPECT/CT Procedure and Preparation of the Pediatric Patient .......... 625

Case Presentations ............................................................................... 627

II.15.1 B-Cell Lymphoblastic Lymphoma, Stage IV Disease with Left and Right Face/Neck Disease and Bilateral Skeletal Involvement of the Lower Extremities (DICOM Images on DVD) ....... 627
II.15.2 Multiple GIST Tumors Metastatic to the Liver and Unconfirmed Pulmonary Chondromas ......................................................... 633
II.15.3 Ewing Sarcoma with Solitary Skeletal Metastasis ..................... 637
II.15.4 ALL with Diffuse Skeletal Involvement, Renal and GIT Involvement; Post-surgical Changes Related to Previous Rotationplasty for Osteogenic Sarcoma .................................................. 640
II.15.5 Stage IV Neuroblastoma with Residual Retrocrural Soft Tissue Disease and Skeletal Metastasis in the Sacrum after Treatment and Post-surgical Changes Left Upper Quadrant (DICOM Images on DVD) ................................................................. 645
II.15.6 Occult Calcaneal Stress Fracture ............................................... 651

References ........................................................................................... 655
Part II Other Clinical Applications ............................................. 657

III.1 Cardiac Hybrid Imaging (PET/CT and SPECT/CT): Assessment of CAD . . . 659
Introduction ................................................................. 659
Imaging Protocols for Hybrid Cardiac Imaging ........................................... 659
CT Imaging for Hybrid Cardiac SPECT/CT and PET/CT .................................. 659
Cardiac SPECT/CT .................................................................. 661
Cardiac PET/CT .................................................................. 661
Quality Control of Cardiac Hybrid Imaging ....................................................... 662
Clinical Applications of Cardiac Hybrid Imaging ................................................ 662
Diagnosis of CAD Using Cardiac Hybrid Imaging .............................................. 662
Risk Assessment Using Cardiac Hybrid Imaging ................................................. 663
Guiding Management of CAD Using Cardiac Hybrid Imaging ............................ 664
Conclusions ........................................................................ 665

Case Presentations .................................................................. 666
III.1.1 Cardiac SPECT/Low Dose CT for Attenuation Correction: Normal Patient with Misregistration .......................................................... 666
III.1.2 Cardiac PET/Low Dose CT for Attenuation Correction: Normal Patient with Misregistration .......................................................... 668
III.1.3 Cardiac SPECT/CCTA: Hemodynamically Significant Lesion in the Territory of the RCA Related to Stenosis in SVG to RCA ................................................... 670
III.1.4 Cardiac SPECT/CCTA: Ischemia in the Inferior Wall Indicating the Hemodynamically Significant Lesion in the RCA ................................................... 673
III.1.5 Normal PET MPS with High Calcium Score (> 1,000) ................................ 676
III.1.6 Moderate Stenosis in the RCA with Normal PET MPS .................................. 679
Protocol ........................................................................ 679
References ........................................................................ 681

III.2 Hybrid Imaging of Benign Skeletal Diseases ................................................. 683
199mTc-MDP SPECT/CT .................................................................. 683
18F-Fluoride PET/CT .................................................................. 685
18F FDG PET/CT .................................................................. 686
Summary ........................................................................ 687
Case Presentations ................................................................ 688
III.2.1 Incidentally Found Fibrous Dysplasia in the Left Tibia ................................... 688
III.2.2 Parosteal Ossifying Lipoma in the Left Fibula ...................................... 691
III.2.3 Giant Cell Tumor of the Sacral Bone and Presacral Region (DICOM Images on DVD) ........................................................................ 694
III.2.4 Chronic Recurrent Multifocal Ostemyelitis in the Thoracic Spine, Knees, Right Humerus, and Scapula (DICOM Images on DVD) ............................................. 699
III.2.5 Osteonecrosis in Both Knees ............................................................. 705
References ........................................................................ 708

III.3 Infectious and Inflammatory Diseases ......................................................... 711
Introduction ........................................................................ 711
Radionuclide Procedures ........................................................................... 711
Skeletal Scintigraphy ............................................................... 711
67Gallium Scintigraphy ............................................................. 712
Labeled Leukocyte Scintigraphy .................................................. 712
18F-FDG Imaging ................................................................. 713
Case Presentations .............................................................. 714
III.3.1 Right Quadriceps Abscess: 67Ga SPECT/CT ...................... 714
III.3.2 Soft Tissue Abscess and Osteomyelitis of the Mandibular
Bone Graft: 67Ga SPECT/CT .................................................. 717
III.3.3 Soft Tissue Infection of the Left Lateral Ankle: 99mTc-MDP
and 111In-WBC SPECT/CT .................................................... 720
III.3.4 Hepatic Abscess: 67Ga SPECT/CT .................................... 724
III.3.5 Osteomyelitis of the Medial Cuneiform and Right First
Metatarsal: 18F-FDG PET/CT .................................................. 726
III.3.6 Infected Right Femoropopliteal Graft: 18F-FDG PET/CT ....... 728
III.3.7A Fever of Unknown Origin: 18F-FDG PET/CT (DICOM
Images on DVD) ............................................................... 731
III.3.7B Dental Abscess 18F-FDG PET/CT .................................... 734
III.3.7C Infected Rental Cyst: 18F-FDG PET/CT ......................... 736
III.3.8 Healing Traumatic L3 Vertebral Fracture: 99mTc-MDP
SPECT/CT and 18F-FDG PET/CT (DICOM Images
on DVD) .............................................................................. 739
References .................................................................................. 744
Subject Index ............................................................................... 747
Hybrid PET/CT and SPECT/CT Imaging
A Teaching File
Delbeke, D.; Israel, O. (Eds.)
2010, XXX, 762 p. 300 illus. in color. With CD-ROM., Hardcover