
Contents

1	Morphology and Microstructure of the Hepatobiliary System	1
1.1	Morphology	1
	Embryology	1
	Liver Lobes and Surfaces	1
	Segments and Areas	3
	Blood Vessels, Bile Ducts, Lymphatics, and Nerves	4
	Hepatic Artery	4
	Portal Vein	5
	Hepatic Vein	5
	Bile Ducts	6
	Lymphatics	8
	Nerves	8
	Biliary Apparatus	10
	Intrahepatic Ducts	10
	Extrahepatic Ducts	10
	Gallbladder	10
	Common Bile Duct	12
	References	12
1.2	Microstructure	13
	Vascular Compartment	14
	Endothelial Cells	15
	Kupffer Cells	15
	Lipocyte or Ito Cells	16
	Pit Cells	16
	Hepatocytes	16
	Bile Canaliculus	17
	Gallbladder and Cystic Duct	17
	Sphincter of Oddi	18
	References	19
2	Liver and Spleen Function	21
2.1	Liver Function	21
	Hepatocyte Uptake	22

Transport Through the Hepatocyte	22
Secretion into Bile Canaliculi	22
Protein Secretion	24
Bile Flow	25
Bile Storage and Concentration by the Gallbladder	25
Gallbladder Emptying	27
References	29
2.2 Spleen Function	30
References	31
3 Imaging Agents	33
Historical Evolution	33
3.1 Morphology and Physiology Imaging Agents	33
Radiocolloids	33
Gold-198 Colloid	34
Technetium-99m-Sulfur Colloid	35
Mechanism of Radiocolloid Uptake	36
Dosimetry of Radiocolloids	37
Technetium-99m-HIDA Agents	38
Labeling	38
Structure-Function Relationship	40
Biokinetics of Tc-99m HIDA agents	41
Other Tc-99m Imaging agents	47
Technetium-99m-DTPA Galactosyl-Human Serum Albumin	49
New SI Units for Measurement of Radiation	49
References	50
3.2 Radiolabeling of Red Blood Cells and Leukocytes	52
Red Blood Cell Labeling with ^{99m} Tc	52
In Vitro Method	52
In Vivo Method	53
Combined In Vivo and In Vitro Method	53
Leukocyte Labeling	53
Indium-111 Oxine	53
^{99m} Tc-HMPAO	54
References	55
3.3 Gallium-67 Citrate	55
Pharmacokinetics	55
References	56
3.4 Somatostatin Receptor Imaging Agent	57
¹¹¹ In-Pentetreotide (Octreoscan)	57
References	58

4	Imaging of the Liver and Spleen Morphology	59
4.1	Imaging with Radiocolloid	59
	Patient Preparation	59
	Normal Liver	59
	Perfusion	59
	Shape, Surface, and Borders	60
	Lobes	62
	Dimensions of the Normal Liver and Spleen	63
	Pattern of Radiocolloid Uptake	64
	Spleen and Bone Marrow Uptake	65
	Appearance of the Normal Liver and Spleen on SPECT Images	65
	Abnormal Liver	67
	Hepatomegaly	67
	Marginal Lesions	67
	Intrahepatic Solitary Focal Lesions	69
	Intrahepatic Multiple Focal Lesions	69
	Intrahepatic Multiple Diffuse Lesion	70
	Relative Accuracy of Diagnostic Tests	70
	References	71
4.2	Adenoma and Focal Nodular Hyperplasia	72
	Adenoma	72
	Focal Nodular Hyperplasia	73
	Scintigraphic Features	74
	Surface Receptors	75
	Treatment	77
	References	77
4.3	Hemangioma	78
	Histopathology	78
	Clinical Presentation	78
	Diagnosis	78
	Blood Pool Scintigraphy	79
	Scintigraphic Features	79
	Treatment	83
	References	85
4.4	Somatostatin Receptor Scintigraphy	85
	Somatostatin Source	85
	Action of Somatostatin	85
	Somatostatin Receptors	86
	Octreotide	86
	Radiolabeling of Octreotide	87
	Indium-111-Pentetreotide (Octreoscan)	87
	Octreoscan Imaging Protocol	88
	Somatostatin Receptor Positive Tumors	88

Radiation Dosimetry	90
References	91
5 Imaging and Quantification of Hepatobiliary Function	93
5.1 Hepatobiliary Imaging	93
Identification of Lobes, Segments, and Areas from ^{99m}Tc -HIDA Images ...	93
Duct Asymmetry	96
Effect of Food Intake on Uptake and Excretion of ^{99m}Tc -HIDA	97
Quantification of Liver Function	97
Quantification of Gallbladder Function	104
Dose and Duration of Infusion of Cholecystokinin	104
Effect of Non-Physiologic Doses of Cholecystokinin	106
Calculation of Gallbladder Ejection Fraction	106
Ejection Fraction with a Fatty Meal Stimulation	107
References	109
5.2 Measurement of Hepatic Arterial vs Portal Venous Blood Flow	110
Data Collection	110
Slope Method	112
Area Method	114
References	116
5.3 Hepatopulmonary Syndrome	116
Clinical Presentation	116
Pathophysiology	117
Diagnosis	117
Scintigraphic Quantification	117
Treatment	119
References	120
5.4 Duodenogastric Bile Reflux	121
Rationale	122
Data Collection and Analysis	122
Duodenogastric Bile Reflux in Health and Disease	125
References	125
5.5 Imaging and Quantification of Hepatocyte Asialoglycoprotein Receptors	126
Data Collection and Analysis	126
References	127
6 Gallbladder, Sphincter of Oddi, Cholecystokinin, and Opioid Interrelationship	129
6.1 Effect of Cholecystokinin on the Gallbladder and Sphincter of Oddi	130
Cholecystokinin	130
Source	130
Structure	131

	Cerulein	132
	Release of CCK	132
	CCK Receptors	132
	Actions of CCK	133
	Dose Response	134
	Effect of a Large Bonus Dose of CCK-8	135
	Sequential CCK Doses	136
	Sphincter of Oddi	137
	Structure and Function	137
	Sphincter Pressure	137
	Action of Cholecystokinin on the Sphincter of Oddi	138
	Gallbladder	139
	Cholecystokinin Receptors	139
	References	140
6.2	Opioids	142
	History of Opioids	142
	Biokinetics of Morphine	142
	Morphine Dose	143
	Action of Morphine on the Sphincter of Oddi	144
	Screening for Opioid Intake	145
	Morphine or Cholecystokinin; One, Neither, or Both?	145
	References	146
7	Intrahepatic Cholestasis	147
	Bile Secretion	147
7.1	Imaging with ^{99m}Tc-HIDA	148
	Etiology of Intrahepatic Cholestasis	148
	Scintigraphic Features of Intrahepatic Cholestasis	152
	References	154
7.2	Imaging with ^{99m}Tc-GSA	155
	Data Collection and Analysis	156
	References	158
8	Extrahepatic Cholestasis	159
8.1	Intraluminal Causes	159
	Clinical Presentation	159
	Choledocholithiasis	161
	Pathophysiology of Bile Duct Obstruction	161
	Cholescintigraphic Features of Total Obstruction of the Common Bile Duct	162
	Functional Recovery Pattern	166
	Hemobilia	167
	Parasites	168

	Miscellaneous Causes	169
	Segmental Biliary Obstruction	169
	Measurement of Duct Size on Cholescintigraphy	169
	References	170
8.2	Wall Thickening	171
	Benign Causes	171
	Stricture	171
	Pathophysiology	172
	Clinical Features	172
	Cholescintigraphic Diagnosis	172
	Cholescintigraphy Accuracy of Biliary Obstruction	175
	Malignant Causes	176
	Cholangiocarcinoma	176
	Clinical Presentation	177
	Carcinoma of the Ampulla of Vater	178
	Stent Patency	178
	References	179
8.3	Combined Intrahepatic and Extrahepatic Cholestasis (Sclerosing Cholangitis)	181
	Primary Sclerosing Cholangitis	181
	Pathophysiology	181
	Secondary Sclerosing Cholangitis	182
	Cholescintigraphic Diagnosis	182
	Therapy	184
	References	184
8.4	Extrinsic Compression	184
	Mirizzi Syndrome	186
	References	186
9	Diseases of the Gallbladder	187
	Natural History of Gallstones	187
	Composition of Gallstones	189
9.1	Chronic Calculous Cholecystitis	189
	Clinical Presentation	189
	Biliary Pain Pathway	190
	Histopathologic Features	190
	Diagnosis of Cholelithiasis	191
	Bile Aspiration	193
	Quantitative Cholescintigraphy	193
	Fatty Meal Stimulation	195
	Effect of Nutrients on Gallbladder Emptying	195
	Causes of Gallbladder Low Ejection Fraction	195
	References	197

9.2	Cystic Duct Syndrome (Chronic Acalculous Cholecystitis)	199
	Clinical Presentation	199
	Histopathologic Feature	199
	Functional Abnormality	200
	Measurement of Gallbladder Ejection Fraction	202
	Therapeutic Response to Cholecystectomy	206
	Standardization of Technique	210
	References	210
9.3	Acute Cholecystitis	211
	Clinical Presentation	212
	Pathophysiology	213
	Cholescintigraphic Approach	214
	Scintigraphic Features of Acute Cholecystitis	215
	Gallbladder Preempting with CCK	218
	Cholangitis	219
	Differential Diagnosis of Acute Cholecystitis	219
	Comparison of Cholescintigraphy and Ultrasound	220
	Application of Bayes' Analysis	221
	Acute Acalculous Cholecystitis	225
	References	225
9.4	Management of Gallbladder Disease	227
	Complications	227
	Perforation of the Gallbladder	227
	Bile Leak	229
	Treatment Bile Leak	230
	Bile Duct Stricture	231
	Prophylactic Cholecystectomy	232
	References	233
10	Biliary Dyskinesia	235
	Pathophysiology	235
	Clinical Presentation	237
	Cholescintigraphic Diagnosis	237
	Gallbladder Phase Imaging	239
	Sphincter of Oddi Spasm	240
	Cystic Duct Syndrome	242
	Differentiation of SOS from CDS	242
	Treatment	243
	Cholecystectomy	243
	Postcholecystectomy Syndrome	244
	Pitfalls	244
	References	245

11	Pediatric Nuclear Hepatology	249
11.1	Congenital Biliary Atresia	250
	Etiology	250
	Clinical Presentation	251
	Cholescintigraphy	251
	Management of Neonatal Cholestasis	256
	References	259
11.2	Cystic Diseases of the Hepatobiliary System	260
	Etiology	261
	Classification of Choledochal Cysts	261
	Intrahepatic Cystic Dilatation (Caroli's Disease)	262
	Diagnosis	263
	Cholescintigraphy	264
	Management of Choledochal Cyst	265
	Cystic Diseases of Liver Parenchyma	265
	Polycystic Liver Disease	265
	References	267
12	Liver Transplantation	269
	Types of Liver Transplantation	269
	Normal Functioning Liver Transplant	271
	Complications	271
	Cholescintigraphy	274
	Auxiliary Liver Transplantation	275
	Differentiation of Native Vs Donor Liver Function	275
	Recovery Pattern in Auxiliary Liver Transplantation	278
	Living Donor Liver Transplantation	278
	Complications	278
	Future Directions	279
	References	279
	Subject Index	283