Index

Page numbers followed by \textit{f} indicate a figure; by \textit{t} a table.

AAI(R)/DDD(R) mode switching, 260–264, 275\textit{f}
AAIsafe\textsuperscript{R} algorithm, 260, 261\textit{f}
acoustic cardiography, 330, 332
acute myocardial repolarization, 50
African-Americans, with reduced LVEF, 15
aldosterone antagonists, 10–11
altered gene expression, from chronic CRT, 46
American College of Cardiology/American Heart Association, 93
American Society of Echocardiography, 118
amiodarone (antiarrhythmic agent), 15
anatomy
  postero-basal right atrium, 159\textit{f}
SA node/right atrial vena cava junction, 61\textit{f}
angiotensin converting enzyme inhibitors (ACEi)
  action on RAAS, 5
  with beta blockers, 4
  clinical effects, 5, 8
  clinical practice recommendations, 8
  mechanisms, 4–5
angiotensin receptor blockers (ARBs)
  clinical effects, 8
  clinical practice recommendations, 9
  clinical trials, 8–9
antiarrhythmic agents, 15
APAF (CRT clinical trials), 142\textit{f}, 146
asymptomatic left ventricular dysfunction, 2–3
atrial conduction system (of heart), 61–62
atrio-ventricular node (AVN), 62–63
AVERT-AF (CRT clinical trial), 143\textit{f}, 146
beta blockers
  with ACEi, 4
  clinical practice recommendations, 13
  effects on LV function/symptoms, 11–12
  effects on outcomes, 12–13
Beta-Blocker Evaluation of Survival Trial (BEST), 13
bifocal right ventricular pacing, 273–275
biochemical consequences of dyssynchrony, 38–39
bisoprolol (beta blocker), 13
biventricular (BiV) pacing, 19, 40, 41\textit{f}, 94, 132\textit{f}, 194\textit{f}
benefits of, 76, 94
creation of RV anodal pacing, 193
electromechanical effect of, 80–83
LV/RV lead location during, 77
OPSITE trial, 146
optimization of AV delay during, 197\textit{f}
progressive LV pre-excitation during, 212\textit{f}
QRS morphology during, 210\textit{f}
Ritter method and, 200
with RV lead in outflow tract, 184
biventricular (BiV) pacing (Contd.)
vs. accelerated idioventricular/junctional rhythm, 190
vs. dual-chamber pacing, 249
BLOCK-HF (CRT clinical trial), 143, 328, 329
bradycardia, 133, 138, 227, 249, 250, 253, 260
brady-tachy syndrome, 255, 260
bucindolol (beta blocker), 13
bumetanide (diuretic), 13
Candesartan in Heart Failure: Assessment of Reduction in Mortality and Morbidity (CHARM)-Added trial, 9, 10–11
cardiac contractility modulation (CCM), 284–294
clinical evidence for, 286–293
FIX-HF-3 study, 287
FIX-HF-4 study, 290, 291–292–294, 293, 294
FIX-HF-5 Phase I study (U.S.), 287, 289, 290
hemodynamic response to signal application, 289
short-term CCM signal applications, 286–287
combining with CRT, 293–294
description, 285
OPTIMIZER System implant, 288f, 290f, 291, 294
rationale for, 285–286
cardiac glycosides. See digitalis glycosides
cardiac resynchronization therapy (CRT), 2, 19–20, 32–33
acute effects
CRT optimization, 42–43, 45
mechanics/energetics, 39–42
chronic effects
altered gene expression, 46
arrhythmia susceptibility, 48–50
electrophysiological alterations, 48–50
global cell-survival signaling enhancement, 46–48
localized molecular remodeling reversal, 46–48
reverse chamber remodeling, 45–46
combining with CCM, 293–294
electromechanical consequences, 76–83
biventricular pacing/AV and VV timing, 80–83
epicardial isochrone maps, 76f
left ventricular pacing, 77–80
map generation, 60f
ongoing trials/unresolved questions, 140
atrial fibrillation, 146–147
minimally symptomatic patients, 140, 145
“nonresponders,” 147–150
responses to (defined), 225f
survival and, 139–140
vs. dobutamine infusion, 39–40, 41f
cardiac resynchronization therapy (CRT), clinical trials, 131–139
APAF, 142f, 146
AVERT-AF, 143f, 146
BLOCK-HF, 143f, 328, 329
CARE HF [21], 135f, 136, 139
COMPANION [29], 134f, 136, 137f, 139–140, 148
CONTAK-CD [10], 133f, 136, 137f, 138f, 140, 145, 148, 150, 328
FREEDOM, 143f
MADIT-CRT, 141f, 145, 328–329
MIRACLE [9], 132f, 136, 137f, 138f
MIRACLE ICD [19], 136, 138f, 328
MUSTIC [7], 132f, 136, 137f, 139, 147
MUSTIC AF [18], 133f, 136, 137f
OPSITE [40], 135f, 146
PACE [39], 328
PATH-CHF [8], 132f, 136, 137f
PATH-CHF II [12], 134f, 136, 137f, 148
PAVE [39], 135f, 146
PEGASUS-CRT, 144f, 149
RAFT, 328
Resynchronization/Defibrillation for Ambulatory Heart Failure Trial, 141f, 145, 329
RETHINQ [20], 139f, 137f, 138f, 148
REVERSE, 141f, 145, 328
SMART-AV, 144f
unresolved questions/ongoing trials, 140
atrial fibrillation, 146–147
minimally symptomatic patients, 140, 145
“nonresponders,” 147–150, 148f
paced vs. native LBBB, 147
cardiac resynchronization therapy (CRT), device failure, 224–225
abnormal device function, 239–241
undersensing/oversensing/loss of capture, 240–241
AV internal optimization, 229–235
differential diagnosis of causes, 239f
dyssynchrony, absence at baseline, 225–229
dyssynchrony, present at baseline/not corrected at implantation, normal device function, 235–241
LV lead position, 229–235
VV interval optimization, 238–239
cardiac resynchronization therapy (CRT), device monitoring
CardioMEMS implantable hemodynamic sensors, 303
HeartPOD implantable hemodynamic sensors, 304
Peak Endocardial Acceleration (PEA) sensor device, 305–306
remote management, 299–301, 303
remote monitoring, 299–301, 303
remote monitoring/integrated systems
CARELINK™ Network by Medtronic, 308–309
Latitude™ by Boston Scientific, 309–312
thoracic impedance monitoring, 301–302
cardiac resynchronization therapy (CRT), device programming, 180–213
anodal stimulation in BiV pacemakers, 193–194
atrial fibrillation/atrial tachyarrhythmia, 190, 192
automatic unlocking of P waves from PVARP, 189–190
AV delay, 197–198, 204
AV interval, 195, 202–204
AV optimization, alternative techniques, 202
AV optimization, invasive/noninvasive, 198
delay, guided by LV dp/dT determination, 201–202
iterative method, 200
Ritter (mitral flow) method, 199–200
velocity-time integral (VTI) methods, 200–201
VTI of transmitial flow, 202
AV relationship, optimal, 195–196
echocardiography, 198
exercise testing, 195, 204
far-field, R-wave oversensing, 190
fusion with spontaneously conducted QRS complex, 203–204
inter-atrial conduction delay, 205
intra-atrial conduction delay (late atrial screening), 205–206
latency/delayed intra-/interventricular conduction, 208–211
lower rate programming, 190
LV pacing output, 182–184
during LV pacing, 182–184
during RV pacing, 182
resynchronization loss below programmed upper rate, 189
short AV delay, 197–198
triggered ventricular pacing, 194–195
twelve-lead electrocardiography, 182
upper-rate response
P wave in the PVARP limitation, 187
pre-empted Wenckebach, 187
programming in upper rate, 187–189
V-V (inter-ventricular) programming, 206–207
impact on effective AV delay, 207–208
timing optimization using ECG, 212–213
cardiac resynchronization therapy (CRT), future research directions
diagnostic imaging
computed tomography, 323–324
magnetic resonance imaging (MRI), 321–323
multimodality imaging techniques, 324–325
nuclear imaging techniques, 320–321
noninvasive optimization techniques, 329–332
acoustic cardiography, 332
continuous noninvasive finger arterial pressure, 332
impedance cardiography, 331
photoplethysmography, 331
ultrasonic continuous-wave Doppler, 331
novel sensor techniques, 329
pacing site selection
diastolic/leadless pacing, 326–328
multisite pacing, 325–326
timing of therapy delivery, 328–329
cardiac resynchronization therapy (CRT), implantation techniques, 158–176
anatomy of postero-basal right atrium, 159f
coronal sinus
anatomy, 157–158, 157f, 158f
cannulation, 159–160
LV lead positioning, 80
venography, 160–161
fluoroscope of middle cardiac vein, 161f
guiding catheter removal, 164–166
LV leads
placement difficulty
causes/solutions, 168–169
surgical placement, 161–163, 173–175
testing, 163–164
RV and RVA lead implantation, 159
target vein selection, 161
cardiac resynchronization therapy (CRT),
implantation techniques (Contd.)
troubleshooting
  access problems, 166, 170
  complication recognition/management, 170–171
coronary sinus dissection, perforation, tamponade, 171–172
device infection, 173
  high pacing thresholds, 166
  loss of capture/lead dislodgement, 172–173
  phrenic nerve stimulation, 166
venous access, 158–159
CardioMEMS implantable hemodynamic sensors, 303
CARE HF [21] (CRT clinical trial), 135, 136, 139
CARELINK™ Network by Medtronic, 308–309, 311
  carvedilol (beta blocker), 13
Carvedilol Post-Infarct Survival Control in LV Dysfunction (CAPRICORN) study, 12
CHARM-Added trial. See Candesartan in Heart Failure: Assessment of Reduction in Mortality and Morbidity (CHARM)-Added trial
COMPANION [29] (CRT clinical trial), 134, 136, 137f, 139–140, 148
COMPASS-HF clinical trial (Chronicle implantable hemodynamic monitor), 303
conduction abnormalities in heart failure
left bundle branch block (LBBB), 68–69
  line of functional block, 72–73
LV activation, 75–76
  LV activation wavefront, 70–72
  LV breakthrough, 6970
right bundle branch block (RBBB), 73
  RV activation, 69, 73–75
sino-atrial dysfunction, 67–68
ventricular activation sequence, 68
CONTAK-CD [10] (CRT clinical trial), 133, 136, 137f, 138, 138f, 140, 145, 148, 150, 328
continuous noninvasive finger arterial pressure, 330, 332
Controlled Rosuvastatin Multinational Trial in Heart Failure (CORONA), 15
coronary sinus anatomy, 157–158, 157f, 158f
  cannulation (in CRT implantation), 159–160
LV lead positioning, 80
venography, 160–161
DAVID II trial, 254
defibrillator (ICD) therapy, 94
device failure, 224–225
  abnormal device function, 239–241
  undersensing/oversensing/loss of capture, 240–241
AV internal optimization, 229–235
differential diagnosis of causes, 239f
dyssynchrony, absence at baseline, 225–229
dyssynchrony, present at baseline/not corrected at implantation, normal device function, 235–241
LV lead position, 229–235
VV interval optimization, 238–239
device monitoring
  CardioMEMS implantable hemodynamic sensors, 303
  HeartPOD implantable hemodynamic sensors, 304
Mid-Heft trial, 301
outpatient management in nonresponders, 314–315
parameters measured by devices, 300f
Peek Endocardial Acceleration (PEA) sensor device, 305–306
remote management, 299–301, 303
remote monitoring, 299–301, 303
remote monitoring/integrated systems
  CARELINK™ Network by Medtronic, 308–309
Latitude™ by Boston Scientific, 309–312
thoracic impedance monitoring, 301–302
Optivol fluid index, 302f
device programming, 180–213, 187–189
  anodal stimulation in BiV pacemakers, 193–194
  atrial fibrillation/atrial tachyarrhythmia, 190–192
  automatic unlocking of P waves from PVARP, 189–190
  AV delay, 197–198, 204
  AV interval, 195, 202–204
  AV optimization, alternative techniques, 202
  AV optimization, invasive/noninvasive, 198–202
  AV relationship, optimal, 195–196
  echocardiography, 198
  exercise testing, 195, 204
  far-field, R-wave oversensing, 190
  fusion with spontaneously conducted QRS complex, 203–204
  inter-atrial conduction delay, 205
index

bradycardia prevention by, 253
DAVID II trial, 254
with long AV delay, 275f
with long AV hysteresis, 275f
premature ventricular beats (PVBs) in, 259f
with RVOT lead, 275f
sinus node disease trial, 264
vs, biventricular pacing, 249
vs, AV ventricular single-chamber pacing, 251, 255, 260
dyssynchronous failing heart (DHF), 37f, 48f, 49f, 50
dyssynchrony of left ventricle. See also cardiac resynchronization therapy (CRT)
absence at baseline, 225–226
arrhythmia susceptibility, 39
assessment
magnetic resonance imaging, 117–118
speckle tracking imaging, 114–116
three-dimensional echocardiography, 116–117
Tissue Doppler Imaging, 110–114
ventricular remodeling, 118–119
biological consequences, 38–39
effect on global function/efficiency, 35–36
gross pathological changes of, 37–38
mechanical dyssynchrony demonstration, 34f
mechanics of, 32–35
regional electrical heterogeneity alterations, 39
relaxation/loading, 36–37
role in heart failure outcomes, 16–20
RV pacing induction of, 39
vs. normal hearts (rendering), 37f
echocardiography. See stress echocardiography;
three-dimensional echocardiography; Tissue Doppler Imaging (TDI);
two-dimensional echocardiography
Edler, Inge, 93
electrical activation of normal heart
atrial conduction system, 61–62
atrio-ventricular node (AVN), 62–63
determination of mechanical activation, 65–66
His-Purkinje system, 63, 64–65
methods for studying, 58–59
body surface mapping, 59
noncontact mapping systems, 58–59
diastolic left ventricular dysfunction, 2–3, 93
diastolic myocardial dysfunction
blood flow Doppler
mitral inflow velocity, 100–102
pulmonary vein inflow velocity, 105–106
clinical use of diastolic indexes, 106–107
left atrial volume, 106
mitral inflow velocity of propagation, 105
Tissue Doppler/mitral annular velocity, 102–105
digitalis glycosides, 14–15
diuretics, 13–14
adverse effects, 14
dyssynchrony improvement from, 37
management of Stage 2 patients, 107
dofetilide (antiarrhythmic agent), 15
Doppler imaging, 94
blood flow Doppler
mitral inflow velocity, 100–102
pulmonary vein inflow velocity, 105–106
Tissue Doppler Imaging assessments, 93, 94
intraventricular dyssynchrony, 110–114
mitral annular velocity, 102–105
peak systolic velocity Sm) of myocardium, 99, 104f
ultrasonic continuous-wave Doppler, 331
dual-chamber pacing, 65–66, 229, 261f
with AAI(R)/DDD(R) mode switching, 260–264, 275f
with bifocal RV pacing, 275f
electrical activation of normal heart
(Contd.)
nonfluoroscopic 3-D contact, 58
normal activation sequence, 64–65
sinus mode (SN), 59–61
electromechanical consequences of CRT,
76–83
biventricular pacing/AV and VV
timing, 80–83
left ventricular pacing, 77–80
diastolic volume (EDV), 17
EnPulse® clinical studies, 264
EnRhythm® clinical studies, 264
Eplerenone Post-Acute Myocardial
Infarction Heart Failure Efficacy
and Survival Study (EPHESUS)
trials, 10
etacrynic acid (diuretic), 13
failure of CRT. See cardiac
resynchronization therapy (CRT),
device failure
FIX-HF-3 CCM signal study, 287
FIX-HF-4 CCM study, 290, 291–292–294
FIX-HF-5 Phase I CCM study (U.S.), 287
FREEDOM (CRT clinical trial), 143
furosemide (diuretic), 13
future directions for CRT research
diagnostic imaging
computed tomography, 323–324
magnetic resonance imaging (MRI),
321–323
multimodality imaging techniques,
324–325
nuclear imaging techniques, 320–321
noninvasive optimization techniques,
329–332
acoustic cardiography, 332
cardiovascular imaging techniques,
321–323
continuous noninvasive finger
arterial pressure, 332
impedance cardiography, 331
photoplethysmography, 331
ultrasonic continuous-wave Doppler,
331
novel sensor techniques, 329
pacing site selection
endocardial/leadless pacing,
326–328
multisite pacing, 325–326
timing of therapy delivery, 328–329
gene expression alteration, in CRT,
46
GISSI-HF trial, 16
heart
anatomy
coronary sinus, 83, 157–158, 157f, 158f,
160
postero-basal right atrium, 159f
SA node/right atrial vena cava
junction, 61f
coronary sinus anatomy, 83, 157
electrical activation of
atrial conduction system, 61–62
atrio-ventricular node (AVN), 62–63
His-Purkinje system, 63, 64–65
methods for studying, 58–59
normal activation sequence, 64–65
sinus node (SN), 59–61
mechanical activation of, 65–66
heart failure
conduction abnormalities
left bundle branch block (LBBB),
68–69
line of functional block, 72–73
LV activation, 75–76
LV activation waveform, 70–72
LV breakthrough, 6970
right bundle branch block (RBBB), 73
RV activation, 69, 73–75
sino-atrial dysfunction, 67–68
ventricular activation sequence, 68
defined/epidemiology, 2, 32
disease statistics, 298–299
mechanical assessment of, 92–119
medical management
ACEi for, 4–5, 6f–7f, 8
aldosterone antagonists, 9–10
antiarrhythmic agents, 15
ARBs, 8–9
ARBs for, 8–9
beta blockers, 11–13
defined/epidemiology, 2
digoxin, 15
digitalis, 14–15
disease management programs, 16
general considerations, 3–4
landmark controlled trials, 6f–7f
pathology of calcium handling in,
285–286
time tracings, 41f
heart failure, dysynchrony role in
outcomes, 16–20
cardiac resynchronization therapy,
19–20
epidemiology and prognosis, 17–19
QRS duration criteria for patient
selection, 16–17, 17f
heart failure with preserved ejection
fraction (HFPEF), 3
HeartPOD implantable hemodynamic
sensors, 304
Herts, Helmut, 93
HFPEF. See heart failure with preserved ejection fraction (HFPEF)
His-Purkinje system
description, 63
electrical activation involvement, 33, 64–65
LBBB and, 69
LV breakthrough and, 69
QRS complex and, 184, 203, 271–273
RV pacing and, 229, 269–273, 271
Holter monitoring system, 262, 262
impedance cardiography, 202, 330, 331
Implantable Cardioverter-Defibrillator (ICD), 159, 190
implantation techniques of CRT, 158–176
anatomy of postero-basal right atrium, 159
Coronary sinus
anatomy, 157–158, 157f, 158f
cannulation, 159–160
LV lead positioning, 80
venography, 160–161
fluoroscope of middle cardiac vein, 161f
guiding catheter removal, 164–166
LV leads
placement difficulty causes/solutions, 168–169f
surgical placement, 161–163, 173–175
testing, 163–164
post-implantation clinical outcomes, 222–224
RV and RVA lead implantation, 159
success rate comparisons, 167f
target vein selection, 161
troubleshooting
access problems, 166, 170
complication
recognition/management, 170–171
coronary sinus dissection, 170
perforation, tamponade, 171–172
device infection, 173
high pacing thresholds, 166
loss of capture/lead dislodgement, 172–173
phrenic nerve stimulation, 166
venous access, 158–159
I° AV block in patients with heart failure, 265
Kaplan-Meier survival curve, 18f, 19f, 292f
Keidel W. D., 93
lateral wall postsystolic displacement (LWPSD), 109–110
Latitude™ by Boston Scientific, 309–312, 310f, 311f, 312f
left bundle branch block (LBBB), 33, 37, 38
abnormal conduction in HF, 68–69
description, 249
flipped transmural patterns of conduction speed, 39
His-Purkinje system and, 69
with longer/narrower QRS duration, 71–72
LV lead placement strategy, 43
morphology of, 17
paced vs., 147
regional circumferential strain plots, 42f
RV-pacing induction of, 72–73
time tracings, 41f
treatment by single-site LV pacing, 78
treatment with single-site LV pacing, 78
vs. right bundle branch block, 45, 74–75
left ventricle (LV) function
BiV pacing benefit to, 146
CRT implantation/local anesthetics, 158
measurements
M-mode/linear, 95
two/three-dimensional, 95–97
regional function, 97–100
RV apical pacing diminishment of, 131, 147
left ventricular (LV) pacing, 43, 44f, 79f, 183–184, 193, 210f
configuration possibilities, 166, 193
electromechanical effect, 77–80
epicardial leads, 176
high thresholds, 166, 193
implantation in contralateral subclavian vein, 170
importance of location, 108
monochamber, 193–194
noncontact mapping, 81f
output programming, 192
QRS morphology during, 182–184
sheathless lead implantation, 165
with simultaneous RV pacing, 82
single site, for treatment of LBBB, 78
single-chamber/QRS duration, 185
vs. RV pacing, 192
left ventricular (LV) remodeling, 2–3
left ventricular dysfunction,
systolic/diastolic. See also
dysynchrony of left ventricle asymtomatic/symptomatic, 2–3
medical management
ACEI, 4–5, 61–71, 8
aldosterone antagonists, 9–10
antiarrhythmic agents, 15
left ventricular dysfunction, systolic/diastolic (Contd.)
- ARBs, 8–9
- beta blockers, 11–13
digitalis, 14–15
disease management programs, 16
diuretics, 13–14
ydralazine-isosorbide dinitrate, 15
statins, 15–16
left ventricular ejection fraction (LVEF), 3, 12, 13
- African-Americans and, 15
  assessment of, 93, 94–95
  Simpson’s rule, 95–96, 96
- CRT and, 19–20
left ventricular enddiastolic (EDV) volume, 17
loop diuretics, 13–14
LWPSD. See lateral wall postsystolic displacement (LWPSD)
MADIT-CRT (CRT clinical trial), 141t, 145, 328–329
magnetic resonance imaging (MRI) assessments, 93, 96–97
LV diysynchrony, 108, 117–118
normal vs. heart failure patients, 112–113
regional LV function, 97
Managed Ventricular Pacing® algorithm, 260, 262, 263f
mechanical activation of the heart, 65–66
mechanical assessment of heart failure, 92–119
- diastolic myocardial dysfunction, 100–107
- systolic myocardial dysfunction, 94–100
metolazone (diuretic), 13
metoprolol succinate (beta blocker), 13
Mid-Heft thoracic device trial, 301
Minnesota Living with Heart Failure Questionnaire (MLWHFQ), 136, 137f, 287, 289f, 290–291
MIRACLE [9] (CRT clinical trial), 132t, 136, 137f, 138f
MIRACLE ICD [11] (CRT clinical trial), 133t, 136, 137f, 139
MIRACLE ICD [19] (CRT clinical trial), 134f, 136, 138f, 328
M-Mode imaging assessments, 93, 94, 99.
  See also Septal to Posterior Wall Mechanical Delay (SPWMD)
LV function measurement, 95
LWPSD index integration with, 109–110
mitral inflow of velocity propagation, 105
SPWMD index integration with, 108–109
wall thickening, 98
MOST trial, 254
MUSTIC [7] (clinical trial), 132t, 136, 137f, 139, 147
MUSTIC AF [18] (clinical trial), 133t, 136, 137f
nebivolol (beta blocker), 13
neurohormonal antagonists, quadruple combinations, 10–11
non-CRT pacing. See cardiac contractility modulation (CCM)
noninvasive optimization techniques, 329–331
nonresponders to CRT, 148f
BiV therapy statistics, 108
causes of failure, 224–225
CCM treatment for, 294
echocardiographic assessment, 94, 119, 230
longitudinal strain delay index cut-off, 116
LV-pacing lead position reevaluation, 112–113
multisite pacing for, 325–326
in non-AV node ablation patients, 146
optimization for, 239, 329
outpatient device management, 314–315
potential etiologies, 147–150, 148f
rates of, 221–222
North America
- heart failure data, 2
- novel sensor technologies, 329
OPSITE [40] (clinical trial), 135f, 146
OPTIMAAL. See Optimal Trial in Myocardial Infarction with Angiotensin II Antagonist Losartan (OPTIMAAL)
Optimal Trial in Myocardial Infarction with Angiotensin II Antagonist Losartan (OPTIMAAL), 8
- optimization of cardiac resynchronization therapy (CRT), 42–43, 45
OPTIMIZER System implant, 288f, 290f, 291, 294
outpatient device management in nonresponders, 314–315
PACE [39] (clinical trial), 328
pacing. See bifocal right ventricular pacing; biventricular (BiV) pacing; cardiac contractility
modulation (CCM); dual-chamber pacing; left ventricular (LV) pacing; single-site left ventricular (LV) pacing

pacing sites
left ventricle, 43, 44
BiV pacing and, 108
breakout of LV activation, 81
site determination, 163–164, 195
wavefront activation, 80
in phrenic nerve stimulation (PNS), 166, 169
right ventricle
alterations of, 73
bifocal pacing, 193, 273–275
His and parahisian pacing, 269–273
outflow tract (RVOT) septum, 265–266, 268, 269
RV outflow tract (RVOT) septum, 265–268
vs. His-bundle pacing, 273
wavefront activation, 80, 83
selection of endocardial/leadless pacing, 326–328
multisite pacing, 325–326
PATH-CHF [8] (clinical trial), 132, 136, 137
PATH-CHF II [12] (clinical trial), 134, 136, 137, 148
patients of devices, chronic management, 297–315
CardioMems implantable hemodynamic sensor, 303
HeartPOD implantable hemodynamic sensor, 304–305
Peak Endocardial Acceleration (PEA) sensor device, 305–306
remote management, 299–301
direct right heart pressure measurement, 303
remote monitoring/integrated systems
CARELINKTM Network by Medtronic, 308–309
LatitudeTM by Boston Scientific, 309–312
thoracic impedance monitoring, 301–302
PAVE [39] (clinical trial), 135f, 146
Peak Endocardial Acceleration (PEA) sensor device, 305–306
pediatric patients with AV block, 250
PEGASUS-CRT (clinical trial), 144f, 149
photoplethysmography, 330, 331
phrenic nerve stimulation (PNS)
avoidance/elimination of, 162, 162f, 181, 230, 327
pacing site choice, 165f, 166, 169f, 234
electrical repositioning, 192–193
postventricular atrial refractory period (PVARP), 180, 187, 188f, 191f
automatic unlocking of P waves from, 189–190
optimal programming of, 189
upper-rate limitation with P wave in, 187
potassium-sparing diuretics, 13
premature ventricular beats (PVBs), in dual-chamber pacing, 259
programming CRT devices, 180–213
anodal stimulation in BiV pacemakers, 193–194
atrial fibrillation/atrial tachyarrhythmia, 190–192
automatic unlocking of P waves from PVARP, 189–190
AV delay, 197–198, 204
AV interval, 195, 202–204
AV optimization, alternative techniques, 202
AV optimization, invasive/noninvasive, 198
delay, guided by LV dP/dT determination, 201–202
iterative method, 200
Ritter (mitral flow) method, 199–200
velocity-time integral (VTI) methods, 200–201
VTI of transmural flow, 202
AV relationship, optimal, 195–196
echocardiography, 198
exercise testing, 195, 204
far-field, R-wave oversensing, 190
fusion with spontaneously conducted QRS complex, 203–204
inter-atrial conduction delay, 205
intra-atrial conduction delay (late atrial screening), 205–206
latency/delayed intra-/interventricular conduction, 208–211
lower rate programming, 190
LV pacing output, 192
optional PVARP programming, 189
phrenic nerve stimulation/electrical repositioning, 192–193
prolonged AV conduction/too-long AV delay, 196–197
QRS morphology during BiV pacing, 184–185
during LV pacing, 182–184
during RV pacing, 182
programming CRT devices (Contd.)
  resynchronization loss below
  programmed upper rate, 189
  short AV delay, 197–198
  triggered ventricular pacing, 194–195
  twelve-lead electrocardiography, 182
  upper-rate response
    P wave in the PVARP limitation, 187
    pre-empted Wenckebach, 187
    programming in upper rate, 187–189
    V-V (inter-ventricular) programming, 206–207
    impact on effective AV delay, 207–208
    timing optimization using ECG, 212–213
PVARP. See postventricular atrial refractory period (PVARP)

QRS morphology
  during BiV pacing, 184–185
  frontal-plane axis of paced QRS complex, 184
  QRS duration, 185
  RV lead at apex location, 184
  RV lead in outflow tract, 184
  ventricular fusion, 184–185
  during LV pacing, 182–184
  during RV pacing, 182
  QRS prolongation
    duration criteria, for patient selection, 16–19
    Kaplan-Meier survival curves, 18f, 19f
    predictive value of, 18
    relationship with LV volumes, 17f

RAAS. See renin-angiotensin aldosterone system (RAAS)
RAFT (CRT clinical trial), 328
Randomized Aldactone Evaluation Study (RALES), 10
remote monitoring/integrated systems
  CARELINK™ Network by Medtronic, 308–309
  Latitude™ by Boston Scientific, 309–312
renal dysfunction, 11
renin-angiotensin aldosterone system (RAAS)
  activation and heart failure, 4, 10
  inhibition of, 5, 10–11
Resynchronization/Defibrillation for Ambulatory Heart Failure Trial, 141f, 145, 329
RETHINQ [20] (clinical trial), 135f, 137f, 138f, 148
REVERSE (clinical trial), 141f, 145, 328
reverse chamber remodeling, from chronic CRT, 45–46
right bundle branch block (RBBB), 148
  CRT benefit for, 32
  description, 73
  with left anterior hemiblock, 75
  vs. LBBB, 74–75, 78
  vs. left bundle branch block, 45, 74–75
right ventricular (RV) pacing, 33, 35–36, 38, 135f, 164f, 183f
  activation of ventricular wavefronts, 80–81
adverse effects
  autonomic/neurohormonal evidence, 250–251
  clinical evidence, 253–254
  echocardiographic evidence, 252–253
  hemodynamic deterioration, 251–252
  histological evidence, 250
  for atrial fibrillation / AV block, 41
  impact on activation sequence, 83
  induction of LV dyssynchrony, 39
  I° AV block in patients with heart failure, 265
LBBB induced by, 72–73
  with simultaneous LV pacing, 82
sites of pacing
  bifocal RV pacing, 193, 273–275
  His and parahisian pacing, 269–273, 271f, 272f
  RV outflow tract (RVOT) septum, 265–268, 268f
unnecessary, avoidance of
  atrial single-chamber pacing mode, 254–255
  dual-chamber mode
    with AV hysteresis, 255–256
    with long AV delay, 256–260
    with mode switching between AAI(R)/DDD(R), 260–264
  vs. LV pacing, 192
right ventricular (RV) pacing, limitations
  in heart failure, 249–254
Ritter (mitral flow) method, 199–200, 202, 329–330, 331
SearchAV+® algorithm, 264
Septal to Posterior Wall Mechanical Delay (SPWMD), 108–110, 109f
Simpson’s rule for LVEF assessment, 95–96, 96f
single-site left ventricular (LV) pacing, 78
sinus mode (SN) of normal heart
  description, 59
  functional heterogeneity of, 59–60
HF patient dysfunction statistic, 60
location/extent of, 61f
Managed Ventricular Pacing® for, 263
sinus node disease (SND), 264
dual-chamber pacing, 257, 260, 263–264
single-chamber pacing, 254–255, 258f
SMART-AV (clinical trial), 144f
spindle tracking imaging (STI), 93, 94, 95
advantages/description, 99–100
use in longitudinal strain assessment, 115f
use in LV dyssynchrony assessment, 114–116, 114f
SPWMD. See Septal to Posterior Wall
Mechanical Delay (SPWMD)
statins, 15–16
stress echocardiography, 93
Studies of Left Ventricular Dysfunction
(SOLVD)-Prevention studies, 5
Study of the Effects of Nebivolol
Intervention on Outcomes and
Rehospitalization in Seniors
(SENIORS) with Heart Failure, 12–13
surgical approach to LV lead placement, 173–174
symptomatic left ventricular dysfunction, 2–3
systolic left ventricular dysfunction, 2–3
systolic myocardial dysfunction, 94–100
linear measurement of LV function, 95
LV function
linear measurements, 95
regional LV function, 97–100
two/three-dimensional measurements, 95–97
thiazides (diuretic), 13
thoracic impedance monitoring, 301–302
three-dimensional echocardiography, 117f
advantages/differences, 94–95, 96
LV function measurements, 95–97
MRI and, 118
regional wall motion abnormalities assessments, 98–99
use in LV dyssynchrony, 116–117
use in LV dyssynchrony assessment, 116–117
Tissue Doppler Imaging (TDI) assessments, 93, 94
intraventricular dyssynchrony, 110–114
mitral annular velocity, 102–105
peak systolic velocity Sm) of myocardium, 99, 104f
regional myocardial strain evaluation, 95
torsemide (diuretic), 13
troubleshooting CRT implantation
access problems, 166, 170
complication recognition/management, 170–171
coronary sinus dissection, perforation, tamponade, 171–172
device infection, 173
high pacing thresholds, 166
loss of capture/lead dislodgement, 172–173
phrenic nerve stimulation, 166
two-dimensional echocardiography, 93, 94, 95–97. See also speckle
tracking (STI)
LV function measurements, 95–97
shortcomings of, 94–95
TDI combination with, 111–112, 115
vs. three-dimensional echocardiography, 98, 119
ultrasonic continuous-wave Doppler, 330, 331
Val-HeFT trial. See Valsartan in Heart
Failure Trial (Val-HeFT) trial
VALIANT trial. See Valsartan in Acute
Myocardial Infarction (VALIANT) trial
Valsartan in Acute Myocardial Infarction
(VALIANT) trial, 8
Valsartan in Heart Failure Trial (Val-HeFT)
trial, 9, 18
video-assisted thorascopic surgery (VATS), 175
V-V (inter-ventricular) programming, 206–207
impact on effective AV delay, 207–208
timing optimization using ECG, 212–213
Wolf-Parkinson-White syndrome, 107, 183, 270f
zones of atrio-ventricular node, 62