

Index

abnormal plaque motion, 66–67
 acetazolamide (Diamox®) test, vasomotor reactivity (VMR), 228–29, 231–32
 acetylcholine/nitroglycerine infusion, endothelial function testing, 48
 acoustic boundaries, ultrasound behavior, 2
 acoustic impedance, 1
 acoustic windows, sonothrombolysis, 191
 acute endovascular stroke therapies, sonothrombolysis, 190–91
 acute ischemic stroke (AIS), 169–78
 carotid duplex ultrasonography (CDU), 169–71
 diagnosis of a lesion amenable to intervention, 174–77
 early re-occlusion, 175–77
 internal carotid artery (ICA), 169–71
 intracranial perfusion imaging, 180, 185–86
 middle cerebral artery (MCA), 170–73
 pathophysiology, 180
 questions, 169
 recanalization, 175–77
 reversed Robin Hood syndrome (RRHS), 177–78
 sonothrombolysis, 190–93
 steno-occlusive disease detection, 169–73
 thrombolysis in brain ischemia (TIBI), 172–74
 transcranial color-coded duplex sonography (TCCS), 169–71
 transcranial Doppler (TCD) sonography, 169–72
 ultrasound assessment of cervical arteries, 169–71
 ultrasound assessment of intracranial arteries, 169–78
 age-dependent changes, vertebral artery (VA), 31
 age-dependent changes of reported FMD values, endothelial function testing, 49
 AIS. *See* acute ischemic stroke

aliasing phenomenon, ultrasound imaging, 7–8
 A-mode (amplitude mode), ultrasound imaging, 6
 amplitude, ultrasound, 1–2
 anastomosis, ophthalmic artery (OA), 165–67
 anatomic considerations, carotid artery, 15
 anatomical aspects, transcranial color-coded duplex sonography (TCCS), 118–19
 anatomical diagnosis intracranial occlusion, 158
 intracranial stenosis, 154–58
 anatomy brachial artery, 49–50
 brain parenchyma imaging, 289–90
 carotid artery stenotic disease, 79–80
 carotid artery wall, 34–35
 cerebral arteries, 118–19
 circle of Willis (coW), 141
 endothelial function testing, 49–50
 functional TCD, 241
 internal carotid artery (ICA), 195–97
 internal jugular veins (IJVs), 278–79
 intracranial venous system, 269–70
 intraorbital vessels, 301
 microembolic signal (MES) detection, 195–97
 middle cerebral artery (MCA), 195–97
 neuro-orbital ultrasound, 301
 optic nerve (ON), 301
 papilla, 301
 sonothrombolysis, 191
 transcranial B-mode sonography (TCS), 289–90
 vertebral artery (VA), 24–26, 195–97
 vertebral venous system (VVS), 278–79
 vertebrobasilar (VB) occlusive disease, 88–89
 angiogenesis, plaque, contrast-enhanced carotid ultrasound, 72–76

anterior cerebral artery (ACA) functional TCD, 253–54
 MCA/ACA bifurcation, transcranial Doppler (TCD) sonography, 143
 transcranial Doppler (TCD) sonography, 143, 144
 anterior communicating artery (ACoA), transcranial Doppler (TCD) sonography, 144
 anterior temporal artery (ATA), posterior cerebral artery (PCA), 135–36
 atherosclerosis. *See also* carotid plaque (CP)
 carotid intima–media thickness (cIMT), 37, 40, 57
 carotid wall imaging, 34–35
 imaging markers, 39–40
 lipid core, 35–36
 measures, 37, 40
 surrogate markers, 41
 atherosclerotic process, pathophysiology, 57–58
 atherosclerotic vertebral artery disease. *See* vertebrobasilar (VB) occlusive disease
 axial resolution, 4
 basilar artery (BA) identification, 143–45
 transcranial color-coded duplex sonography (TCCS), 136–37
 transcranial Doppler (TCD) sonography, 143–46
 BBB. *See* blood–brain barrier
 Behçet disease, 115
 BFV. *See* blood flow velocity
 bilateral carotid occlusive disease, vasomotor reactivity (VMR), 234
 blood–brain barrier (BBB) intracranial perfusion imaging, 184–85
 opening, 11–12
 blood flow velocity (BFV). *See also* flow velocity (FV) internal jugular veins (IJVs), 282–83 vertebral venous system (VVS), 282–83

Index

- blood volume flow (BVF)
 - internal jugular veins (IJVs), 280–81, 282–83
 - vertebral venous system (VVS), 280–81, 282–83
- B-mode (brightness mode),
 - ultrasound imaging, 7
- B-mode imaging of morphology,
 - grading carotid stenosis, 82
- bolus kinetics, intracranial perfusion imaging, 181–84
- brachial artery, anatomy, 49–50
- brain death. *See* cerebral circulatory arrest
- brain parenchyma imaging. *See also* transcranial B-mode sonography (TCS)
 - anatomy, 289–90
 - future directions, 297–98
 - steps of investigation, 290–92
 - techniques, 288
- brain perfusion imaging, low mechanical index (MI) real-time perfusion, scanning, 11
- breath-holding or apnea test, vasomotor reactivity (VMR), 228–29, 231, 232
- BVF. *See* blood volume flow
- CA. *See* catheter intra-arterial angiography; cerebral autoregulation
- CAD. *See* cervical artery dissection
- carotid artery stenotic disease. *See also* grading carotid stenosis
 - anatomy, 79–80
 - hemodynamic effects, 80–81
 - velocities in a stenosis, 80–82
- carotid artery total occlusion, vasomotor reactivity (VMR), 234–35
- carotid duplex ultrasonography (CDU), cervical arteries, 169–71
- carotid intima–media thickness (cIMT)
 - atherosclerosis measure, 37, 40, 57
 - contrast-enhanced carotid ultrasound, 69–71
 - plaque ultrasound protocol, 37–39
 - stroke risk, 40
 - technique, 58
- carotid occlusion, contrast-enhanced
 - carotid ultrasound, 71–72
- carotid occlusive disease, vasomotor reactivity (VMR), 233–34
- carotid plaque (CP). *See also* atherosclerosis
 - atherosclerosis measure, 37, 40
 - effect, 62
 - Geroulakos scale, 60–61
- Gray-Weale scale, 60–61
- gray-scale median (GSM), 60
- histological composition, 60–61
- new directions, 62–63
- plaque ultrasound protocol, 37–39
 - scanning tips, 62
 - stroke risk, 41
 - technique, 58–62
 - texture classification, 60
- carotid protocol, 15–21
 - anatomic considerations, 15
 - common carotid artery (CCA), 17–18
 - elongation, kinking and coiling, 21
 - external carotid artery (ECA), 18–21
 - general study protocol, 16–21
 - information to collect, 21
 - internal carotid artery (ICA), 17–18
 - position of the examiner and the patient, 16
- carotid surgery, vasomotor reactivity (VMR), 235
- carotid ultrasound imaging, 57–63
 - carotid wall imaging, 34–43
 - anatomy, carotid artery wall, 34–35
 - atherosclerosis, 34–36
 - atherosclerosis measure, 37, 40
 - carotid intima–media thickness (cIMT), 37–39, 40
 - clinical value, 40–41
 - future perspectives, 42–43
 - magnetic resonance imaging (MRI), 39
 - pathophysiology, carotid artery wall, 34–35
 - physiology, carotid artery wall, 34–35
 - plaque ultrasound protocol, 37–39
 - screening value, 42
 - technical aspects, 36–37
- carpal tunnel syndrome (CTS), nerve ultrasonography (NUS), 308
- catheter intra-arterial angiography (CA), vertebral artery (VA), 23
- catheter placement, internal jugular veins (IJVs), 284
- CCA. *See* common carotid artery
- CCAD. *See* common carotid artery dissection
- CCDS. *See* color-coded duplex sonography
- CCSVI. *See* chronic cerebrospinal venous insufficiency
- CDU. *See* carotid duplex ultrasonography
- CE-MRA. *See* contrast enhanced MRA
- central venous pressure (CVP), internal jugular veins (IJVs), 285
- cerebral arteries, anatomy, 118–19
- cerebral autoregulation (CA), 215–25
- brain traumatic injury, 223
- cerebral perfusion pressure (CPP), 222–23
- cerebrovascular disease, 224
- clinical settings, 223–25
- concepts, 215
- critical care conditions, 259–60
- critical closing pressure (CrCP), 215–16
- dynamic CA, 218–23
- future directions, 225
- historical background, 215
- Lassen's curve, 215
- mean velocity index (Mx), 222–23
- measuring techniques, 216–23
- optimal CPP, 223
- physiological control, 215–16
- postural changes, 221
- pressure-reactivity index (PRx), 222–23
- resistance-area product (RAP), 215–16
- spontaneous dynamic CA, 221–23
- static CA, 217–18
- synchronized breathing, 220–21
- syncope, 224–25
- thigh cuffs release test (TCRT), 218–19
- Tiecks' model, 219
- time correlation methods, 222–23
- transcranial Doppler (TCD) sonography, 259–60
- transfer function analysis, 221–22
- transient hyperemic response test (THRT), 220
- Valsalva maneuver (VM), 219–20
- cerebral circulatory arrest, 262–67
 - computed tomographic angiography (CTA), 263–64
 - detection techniques, 262–64
 - digital subtraction angiography (DSA), 262–63
 - imaging tips, 264
 - pathophysiological concept, 262
 - perfusion scintigraphy, 263
 - questions to ultrasound, 264
 - steps of investigation, 264–67
 - ultrasound flow patterns, 264
 - ultrasound systems and settings, 264
- cerebral perfusion pressure (CPP), cerebral autoregulation (CA), 222–23
- cerebral vein and sinus thrombosis (CVST)
 - future directions, 275
- intracranial venous system, 269, 272–75

cerebrovascular disease, cerebral autoregulation (CA), 224 cervical arteries carotid duplex ultrasonography (CDU), 169–71 ultrasound assessment, 169–71 cervical artery dissection (CAD), 99–109 common carotid artery dissection (CCAD), 104–6 diagnosis, 99–101 imaging tips, 101 incidence, 99 internal carotid artery dissection (ICAD), 101–5 questions, 101 stroke risk, 99 ultrasound vs. MRI, 99–101 vertebral artery dissection (VAD), 106–7 cervical artery vasculitides, 111–15 cervical vein inflammation, 115 color-coded duplex sonography (CCDS), 111 duplex sonography (DS), 111 infectious and parainfectious vasculitis, 115 large vessel vasculitis (LVV), 111–15 medium and small vessel vasculitis, 115 small (to medium) vessel vasculitis, 115 varicella zoster virus (VZV), 115 cervical vein inflammation, 115 Behçet disease, 115 Lemierre syndrome, 115 cervical veins. *See* internal jugular veins (IJVs); vertebral venous system (VVS) chest CT and pulmonary angiography, right-to-left shunts (RLS), 206 chronic cerebrospinal venous insufficiency (CCSVI), multiple sclerosis, 285 cIMT. *See* carotid intima–media thickness circle of Willis (coW) anatomy, 141 collateral pathways, 166–68 measuring techniques, 140–41 transcranial color-coded duplex sonography (TCCS), 118–19, 126–27 transcranial Doppler (TCD) sonography, 140–41, 191 circulus arteriosus cerebri (Willisi). *See* circle of Willis CO₂ inhalation, vasomotor reactivity (VMR), 228–29, 231, 232

coiling. *See* elongation, kinking and coiling collateral pathways, 165–68 anastomosis, 165–67 caveats, 167 circle of Willis (coW), 166–68 clinical relevance, 168 collateral systems, 165–68 common carotid artery (CCA), 165–67 effectiveness, 168 external carotid artery (ECA), 165–67 hemodynamics, 165–66 internal carotid artery (ICA), 165–67 occlusion of the common carotid artery (oCCA), 165–67 ophthalmic artery (OA), 165–67 pitfalls, 167 vertebral artery (VA), 26, 165–66 color-coded duplex sonography (CCDS) cervical artery vasculitides, 111 giant cell arteritis (GCA), 112–14 Takayasu arteritis (TA), 114–15 vertebrobasilar (VB) occlusive disease, 89–92 color Doppler flow imaging, ultrasound imaging, 7–8 color imaging and flow field, grading carotid stenosis, 82 common carotid artery (CCA) collateral pathways, 165–67 general study protocol, 17–18 plaque ultrasound protocol, 37–39 common carotid artery dissection (CCAD), 104–6 computed tomographic angiography (CTA) cerebral circulatory arrest, 263–64 intracranial venous system, 269 vertebral artery (VA), 23 congenital variations, vertebral artery (VA), 24–26 continuous-wave (CW) Doppler, 1–3, 5–6 velocity measurement, grading carotid stenosis, 82–83 contrast enhanced MRA (CE-MRA), vertebral artery (VA), 23 contrast transesophageal echocardiography (cTEE), right-to-left shunts (RLS), 206 contrast-enhanced carotid ultrasound, 64–77 carotid intima media thickness (cIMT), 69–71 carotid occlusion, 71–72 future directions, 75–77 image interpretation, 69–76 machine set-up, 68–69 morphology definition, 69–73 plaque angiogenesis, inflammation, 72–75 plaque angiogenesis, quantification, 75–76 plaque ulceration and surface rupture, 70–71 plaque vascularization, inflammation, 72–75 plaque vascularization, quantification, 75–76 severe, preocclusive stenosis and pseudo-occlusion, 72–73 unclear cases, 72–73 unstable plaque definition, 64–68 contrast-enhanced transcranial Doppler sonography (cTCD) diseases other than stroke, 209–10 evaluation of test results, 209 imaging tips, 207–8 microembolic signal (MES) detection, 207–8 questions, 207 right-to-left shunt (RLS), 206–12 steps of investigation, 208–10 stroke patients, 210–12 coW. *See* circle of Willis CP. *See* carotid plaque CPP. *See* cerebral perfusion pressure CrCP. *See* critical closing pressure critical care conditions cerebral autoregulation (CA), 259–60 flow velocity (FV), 259–60 imaging tips, 260–61 indications and findings, 259–60 metabolic regulation, 259–60 pulsatility indices, 259–60 specificities of measurements, 258–59 transcranial Doppler (TCD) sonography, 258–61 critical closing pressure (CrCP), cerebral autoregulation (CA), 215–16 CTA. *See* computed tomographic angiography cTCD. *See* contrast-enhanced transcranial Doppler sonography cTEE. *See* contrast transesophageal echocardiography CTS. *See* carpal tunnel syndrome CVP. *See* central venous pressure CVST. *See* cerebral vein and sinus thrombosis CW Doppler. *See* continuous-wave Doppler

Index

data collecting/storing, vertebral artery (VA), 32
 destruction kinetics, intracranial perfusion imaging, 181–84
 Diamox® (acetazolamide) test, vasomotor reactivity (VMR), 228–29, 231–32
 digital subtraction angiography (DSA) cerebral circulatory arrest, 262–63 intracranial venous system, 269
 documentation transcranial Doppler (TCD) sonography, 149–51 vertebral artery (VA), 31 dolichoectasia, 21 Doppler ultrasound, 4–5 drug delivery, targeted, 12 DS. *See* duplex sonography DSA. *See* digital subtraction angiography duplex image, ultrasound imaging, 7 duplex sonography (DS), 111. *See also* color-coded duplex sonography (CCDS), cervical artery vasculitides
 early re-occlusion, acute ischemic stroke (AIS), 175–77
 early temporal branch (ETB), middle cerebral artery (MCA), M1 main stem, 134–35
 ECA. *See* external carotid artery echogenicity, unstable plaque definition, 65
 EEG/visual-evoked potentials (VEP), functional TCD, 246–48 elongation, kinking and coiling external carotid artery (ECA), 21 internal carotid artery (ICA), 21 endothelial function testing, 48–49 acetylcholine/nitroglycerine infusion, 48 age-dependent changes of reported FMD values, 49 anatomy, 49–50 finger plethysmography, 49 flow-mediated vasodilatation (FMD) frequency, ultrasound, 1–2 functional TCD, 239–54. *See also* transcranial Doppler (TCD) sonography anatomy, 241 anterior cerebral artery (ACA), 253–54 arterial pCO₂ influence, 243 associative tasks, 250–52 averaging techniques, 243–44 blood pressure influence, 243 complex spatial and cognitive tasks, 250–52 Doppler probes, 242–43 EEG/visual-evoked potentials (VEP), 246–48 examination technique, 243 flow velocity (FV), 242, 245–47 future directions, 253–54 heart rate influence, 243 imaging tips, 241–43 literature review, 248, 252–54 middle cerebral artery (MCA), 249–53 motor tasks, 250–52 non-ultrasound techniques, 239 ETB. *See* early temporal branch

examination technique functional TCD, 243 nerve ultrasonography (NUS), 306–7 transcranial color-coded duplex sonography (TCCS), 119–23 vertebral artery (VA), 26–27 external carotid artery (ECA) collateral pathways, 165–67 elongation, kinking and coiling, 21 general study protocol, 18–21 versus internal carotid artery (ICA), 17–18
 finger plethysmography, endothelial function testing, 49 flow velocity (FV). *See also* blood flow velocity (BFV) critical care conditions, 259–60 functional TCD, 242, 245–47 insonation depth, 5 intracranial venous system, 271–73, 275–76 pulse repetition frequency (PRF), 5 transcranial Doppler (TCD) sonography, 259–60 flow-mediated vasodilatation (FMD) age-dependent changes of reported FMD values, 49 endothelial function testing, 49 stereotactic probe-holder for FMD measurement, 50–51 FMD. *See* flow-mediated vasodilatation frequency, ultrasound, 1–2 functional TCD, 239–54. *See also* transcranial Doppler (TCD) sonography anatomy, 241 anterior cerebral artery (ACA), 253–54 arterial pCO₂ influence, 243 associative tasks, 250–52 averaging techniques, 243–44 blood pressure influence, 243 complex spatial and cognitive tasks, 250–52 Doppler probes, 242–43 EEG/visual-evoked potentials (VEP), 246–48 examination technique, 243 flow velocity (FV), 242, 245–47 future directions, 253–54 heart rate influence, 243 imaging tips, 241–43 literature review, 248, 252–54 middle cerebral artery (MCA), 249–53 motor tasks, 250–52 non-ultrasound techniques, 239

physiological mechanism of neurovascular coupling, 240–42 posterior cerebral artery (PCA), 244–48 questions, 239–40 recordings and examination, 243 relevant arteries, 241 speech, hemispheric dominance, 249–50 steps of investigation, 243–44 transcranial Doppler (TCD) sonography, 239–40 ventilation influence, 243 future directions brain parenchyma imaging, 297–98 cerebral autoregulation (CA), 225 cerebral vein and sinus thrombosis (CVST), 275 contrast-enhanced carotid ultrasound, 75–77 endothelial function testing, 52–49 functional TCD, 253–54 intracranial perfusion imaging, 187 microembolic signal (MES) detection, 201 neuro-orbital ultrasound, 305 sonothrombolysis, 192–93 transcranial B-mode sonography (TCS), 297–98 transcranial Doppler (TCD) sonography, 151–52 vasomotor reactivity (VMR), 236 vertebrobasilar (VB) occlusive disease, 96 future perspectives, carotid wall imaging, 42–43 FV. *See* flow velocity GANCS (granulomatous angiitis of the CNS), 115 GCA. *See* giant cell arteritis gCCT. *See* global cerebral circulation time gender-dependent changes, vertebral artery (VA), 31 generalized neuropathies, nerve ultrasonography (NUS), 310 Geroulakos scale, carotid plaque (CP), 60–61 giant cell arteritis (GCA), 111–14 color-coded duplex sonography (CCDS), 112–14 incidence, 112 magnetic resonance imaging (MRI), 112–14 prevalence, 112 global cerebral circulation time (gCCT), internal jugular veins (IJVs), 282, 285

grading carotid stenosis, 79–86,
See also carotid artery stenotic disease
 B-mode imaging of morphology, 82
 color imaging and flow field, 82
 continuous-wave (CW) Doppler, velocity measurement, 82–83
 estimating velocities tips, 83–84
 further directions, 85–86
 hemodynamic effects, 84–85
 imaging tips, 83–84
 pulsed-wave (PW) Doppler, velocity measurement, 82–83
 questions, 79
 radiologic methods, 79
 steps of investigation, 84–85
 ultrasonic methods, 79
 ultrasonic modalities, 82–83
 granulomatous angiitis of the CNS (GANCS), 115
 Gray–Weale scale, carotid plaque (CP), 60–61
 gray-scale median (GSM), carotid plaque (CP), 60
 hemodynamic effects
 carotid artery stenotic disease, 80–81
 grading carotid stenosis, 84–85
 hemodynamic findings, internal carotid artery dissection (ICAD), 101–5
 hemodynamic parameters
 transcranial color-coded duplex sonography (TCCS), 123–26
 vertebral artery (VA), 30–31
 hemodynamic studies, intracranial venous system, 276
 hemodynamics
 collateral pathways, 165–66
 internal jugular veins (IJVs), 282–83
 law of Hagen–Poiseuille, 165–66
 vertebral venous system (VVS), 282–83
 high-frequency ultrasound, attenuation, 2–4
 high-intensity transient signals (HITS). *See* microembolic signal (MES) detection
 high mechanical index (MI) perfusion imaging, 180–81
 Horton's disease. *See* giant cell arteritis (GCA)
 hypoplasia, vertebral artery (VA), 25–26
 ICA. *See* internal carotid artery
 ICAD. *See* internal carotid artery dissection

IJVS. *See* internal jugular veins
 IJVVI. *See* internal jugular vein valve insufficiency
 imaging tips
 cerebral circulatory arrest, 264
 cervical artery dissection (CAD), 101
 contrast-enhanced transcranial Doppler sonography (CTCD), 207–8
 critical care conditions, 260–61
 endothelial function testing, 50–51
 functional TCD, 241–43
 grading carotid stenosis, 83–84
 intracranial perfusion imaging, 185–86
 intracranial venous system, 270
 microembolic signal (MES) detection, 197–98
 neuro-orbital ultrasound, 301–2
 right-to-left shunts (RLS), 207–8
 sono-thrombolysis, 191
 transcranial B-mode sonography (TCS), 290
 transcranial Doppler (TCD) sonography, 141–42, 260–61
 vasomotor reactivity (VMR), 230
 vertebral artery dissection (VAD), 106
 vertebrobasilar (VB) occlusive disease, 89–90
 IMT/cIMT. *See* carotid intima–media thickness
 infectious and parainfectious vasculitis, 115
 insonation depth
 flow velocity (FV), 5
 pulse repetition frequency (PRF), 5
 intensive care units (ICU). *See* critical care conditions
 internal carotid artery dissection (ICAD), 101–5
 false negative findings, 103
 hemodynamic findings, 101–5
 morphological findings, 101
 recurrence of dissection, 104–5
 ultrasound findings, 101–5
 internal carotid artery (ICA)
 acute ischemic stroke (AIS), 169–71
 anatomy, 195–97
 C6 segment, TCCS, 131–33
 carotid duplex ultrasonography (CDU), 169–71
 collateral pathways, 165–67
 elongation, kinking and coiling, 21
 vs. external carotid artery (ECA), 17–18
 general study protocol, 17–18
 plaque ultrasound protocol, 37–39

transcranial color-coded duplex sonography (TCCS), 131–33
 internal jugular vein valve insufficiency (IJVVI), 284–85
 internal jugular veins (IJVs), 278–85
 anatomy, 278–79
 blood flow velocity (BFV), 282–83
 blood volume flow (BVF), 280–81, 282–83
 catheter placement, 284
 central venous pressure (CVP), 285
 chronic cerebrospinal venous insufficiency (CCSVI), 285
 global cerebral circulation time (gCCT), 282, 285
 hemodynamics, 282–83
 IJV compression tests, 281–82
 internal jugular vein valve insufficiency (IJVVI), 284–85
 ultrasonography, 279–82
 intracranial arterial dissection, 107
 intracranial perfusion imaging, 180–87
 acute ischemic stroke (AIS), 180, 185–86
 blood–brain barrier (BBB), 184–85
 bolus kinetics, 181–84
 choosing the method, 184
 destruction kinetics, 181–84
 future directions, 187
 high mechanical index (MI) perfusion imaging, 180–81
 imaging tips, 185–86
 Levovist®, 184–85
 low mechanical index (MI) perfusion imaging, 181–82
 microbubble destruction, 181–84
 microvascular imaging (MVI), 186
 Optison®, 184–85
 pathophysiology, 180
 questions, 184–85
 refill kinetics, 181–84
 safety, 184–85
 SonoVue®, 184–85
 intracranial segment of ICA (iICA), transcranial Doppler (TCD) sonography, 143
 intracranial stenosis/occlusion, 154–63
 anatomical diagnosis, 158
 anatomical diagnosis, stenosis, 154–58
 diagnosis of nature, 160–62
 follow-up, 162–63
 functional diagnosis, 158–60
 questions, 154
 transcranial color-coded duplex sonography (TCCS), 154–60, 163

Index

- intracranial stenosis/occlusion (*cont.*)
 - transcranial Doppler (TCD)
 - sonography, 154–60, 163
 - ultrasound assessment of intracranial arteries, 169–78
 - intracranial venous system, 269–76
 - anatomy, 269–70
 - cerebral vein and sinus thrombosis (CVST), 269, 272–75
 - computed tomographic angiography (CTA), 269
 - digital subtraction angiography (DSA), 269
 - flow velocity (FV), 271–73, 275–76
 - hemodynamic studies, 276
 - imaging tips, 270
 - intracranial pressure, 276
 - literature review, 273
 - magnetic resonance angiography (MRA), 269
 - non-ultrasound techniques, 269
 - questions, 269
 - reproducibility and normal values, 271–73
 - steps of investigation, 270–71
 - transcranial color-coded duplex sonography (TCCS), 273
 - transcranial Doppler (TCD)
 - sonography, 273
 - transient global amnesia (TGA), 276
 - vein visibility, 270
 - intraorbital vascularization, neuro-orbital ultrasound, 300
 - intraorbital vessels, anatomy, 301
- Kawasaki disease, 115
- kinking. *See* elongation, kinking and coiling
- large vessel vasculitis (LVV), 111–15
 - giant cell arteritis (GCA), 111–14
 - Takayasu arteritis (TA), 111–12, 114–15
- L-arginine test, vasomotor reactivity (VMR), 228–29
- Lassen's curve, cerebral autoregulation (CA), 215
- lateral resolution, 4
- law of Hagen–Poiseuille, hemodynamics, 165–66
- leg-cuff method, vasomotor reactivity (VMR), 228–29, 231, 232
- Lemierre syndrome, 115
- Levovist®, intracranial perfusion imaging, 184–85
- limitations of ultrasound assessment, 39
- screening value, 42
- vertebral artery (VA), 23–24
- lipid core, atherosclerosis, 35–36
- low mechanical index (MI) perfusion imaging, 181–82
- low mechanical index (MI) real time perfusion scanning, brain perfusion imaging, 11
- low-frequency ultrasound, attenuation, 2–4
- LVV. *See* large vessel vasculitis
- M1 branching pattern, middle cerebral artery (MCA), 133–34
- magnetic resonance angiography (MRA)
 - intracranial venous system, 269
 - vertebral artery (VA), 23
- magnetic resonance imaging (MRI)
 - carotid wall imaging, 39
 - giant cell arteritis (GCA), 112–14
 - vs. ultrasound imaging, CAD diagnosis, 99–101
- markers, endothelial function testing, 49
- MCA. *See* middle cerebral artery
- mean velocity index (Mx), cerebral autoregulation (CA), 222–23
- MES detection. *See* microembolic signal (MES) detection
- metabolic regulation
 - critical care conditions, 259–60
 - transcranial Doppler (TCD)
 - sonography, 259–60
- microbubble based contrast agents, 8–10
 - acoustic cavitation, 9
 - behavior of microbubbles in acoustic field, 9–10
 - bioeffects on vascular permeability, 10
 - characteristics, 8–9
- microbubble destruction, intracranial perfusion imaging, 181–84
- microembolic signal (MES) detection
 - anatomy, 195–97
 - clinical conditions, 195
 - contrast-enhanced transcranial Doppler sonography (cTCD), 207–8
 - future directions, 201
- imaging tips, 197–98
- questions, 195
- steps of investigation, 198–201
- techniques, 195
- transcranial Doppler (TCD)
 - sonography, 195–201
 - unstable plaque definition, 67
- vertebrobasilar (VB) occlusive disease, 96
- microvascular imaging (MVI), intracranial perfusion imaging, 186
- middle cerebral artery (MCA)
 - acute ischemic stroke (AIS), 170–73
 - anatomy, 195–97
 - early temporal branch (ETB), M1 main stem, 134–35
 - functional TCD, 249–53
 - M1 branching pattern, 133–34
 - MCA/ACA bifurcation, transcranial Doppler (TCD) sonography, 143
 - transcranial color-coded duplex sonography (TCCS), 133–35
 - transcranial Doppler (TCD) sonography, 143
- molecular ultrasound, 12
- morphological findings, internal carotid artery dissection (ICAD), 101
- Morton's metatarsalgia, nerve ultrasonography (NUS), 309
- MRA. *See* magnetic resonance angiography
- MRI. *See* magnetic resonance imaging
- multiple sclerosis, chronic cerebrospinal venous insufficiency (CCSVI), 285
- MVI. *See* microvascular imaging
- Mx. *See* mean velocity index
- nerve ultrasonography (NUS), 306–11
 - carpal tunnel syndrome (CTS), 308
 - compressive neuropathies, 308–9
 - examination technique, 306–7
 - generalized neuropathies, 310
 - Morton's metatarsalgia, 309
 - neurofibromas, 309–10
 - pathological findings, 308–11
 - peripheral nerve tumors, 309–10
 - polyneuropathies, 310
 - schwannoma (neurinoma), 309–10
 - technical requirements, 306–7
 - traumatic nerve lesions, 310–11
 - ulnar neuropathy in the elbow region (UNE), 308–9
- neurinoma (schwannoma), nerve ultrasonography (NUS), 309–10
- neurodegenerative disorders, transcranial B-mode sonography (TCS), 292–96
- neurofibromas, nerve ultrasonography (NUS), 309–10
- neuro-intensive care medicine, transcranial B-mode sonography (TCS), 297
- neuro-orbital ultrasound, 300–5
 - anatomy, 301
 - future directions, 305
 - imaging tips, 301–2
- intraorbital vascularization, 300
- optic nerve (ON), 303
- optic nerve (ON) measurement, 300

- orbital vessels, 304
 papilla edema measurement, 300
 papilla examination, 302–3
 probe selection, 301
 questions, 300–1
 safety, 302
 steps of investigation, 302
 neurovascular coupling, physiological mechanism, 240–42
 non-microbubble-based contrast agents, 10–11
 non-ultrasound techniques, 239
 atherosclerotic vertebral artery disease, 88
 posterior circulation occlusive disease (PCOD), 88
 vasomotor reactivity (VMR) measurement, 228–30
 vertebral artery (VA), 23
 NUS. *See* nerve ultrasonography
 Nyquist limit, 5–6
- OA. *See* ophthalmic artery
 oCCA. *See* occlusion of the common carotid artery
 occipitotemporal artery (OTA), posterior cerebral artery (PCA), 135–36
 occlusion of the common carotid artery (oCCA), collateral pathways, 165–67
 ON. *See* optic nerve
 ophthalmic artery (OA)
 anastomosis, 165–67
 collateral pathways, 165–67
 insonation technical settings, 20–21
 transcranial color-coded duplex sonography (TCCS), 133
 transcranial Doppler (TCD) sonography, 143
 transtemporal insonation, 133
 optic nerve (ON)
 anatomy, 301
 measurement, 300
 neuro-orbital ultrasound, 303
 Optison®, intracranial perfusion imaging, 184–85
 orbita. *See* neuro-orbital ultrasound
 orbital vessels
 intraorbital vessels, anatomy, 301
 neuro-orbital ultrasound, 304
 OTA. *See* occipitotemporal artery
- PANCS (primary angiitis of the CNS), 115
 papilla, anatomy, 301
 papilla edema measurement, neuro-orbital ultrasound, 300
 papilla examination, neuro-orbital ultrasound, 302–3
- pathophysiology
 acute ischemic stroke (AIS), 180
 atherosclerotic process, 57–58
 carotid artery wall, 34–35
 intracranial perfusion imaging, 180
 PCA. *See* posterior cerebral artery
 PCNSV (primary CNS vasculitis), 115
 PCOD. *See* posterior circulation occlusive disease
 perfusion imaging, intracranial. *See* intracranial perfusion imaging
 perfusion scintigraphy, cerebral circulatory arrest, 263
 peripheral nerve tumors, nerve ultrasonography (NUS), 309–10
 physiological control, cerebral autoregulation (CA), 215–16
 physiological mechanism of neurovascular coupling, functional TCD, 240–42
 physiology
 carotid artery wall, 34–35
 vasomotor reactivity (VMR), 230
 piezoelectric crystals, 1–3
 plaque angiogenesis,
 contrast-enhanced carotid ultrasound, 72–76
 plaque motion analysis, 66–67
 plaque ulceration and surface rupture, contrast-enhanced carotid ultrasound, 70–71
 plaque ultrasound protocol. *See also* carotid plaque (CP)
 carotid intima–media thickness (cIMT), 37–39
 common carotid artery (CCA), 37–39
 internal carotid artery (ICA), 37–39
 plaque vascularization,
 contrast-enhanced carotid ultrasound, 72–76
 polyarteritis nodosa, 115
 polyneuropathies, nerve ultrasonography (NUS), 310
 position of the examiner and the patient, carotid protocol, 16
 posterior cerebral artery (PCA)
 anterior temporal artery (ATA), 135–36
 cortical branches, 135–36
 functional TCD, 244–48
 occipitotemporal artery (OTA), 135–36
 transcranial color-coded duplex sonography (TCCS), 135–36
 transcranial Doppler (TCD) sonography, 144
 posterior circulation occlusive disease (PCOD), 87–88
- non-ultrasound imaging techniques, 88
 posterior communicating artery (PCoA), transcranial Doppler (TCD) sonography, 144
 posterior inferior cerebellar artery (PICA), transcranial Doppler (TCD) sonography, 145
 postural changes, cerebral autoregulation (CA), 221
 power Doppler mode, ultrasound imaging, 8
 pressure-reactivity index (PRx), cerebral autoregulation (CA), 222–23
 PRF. *See* pulse repetition frequency
 primary angiitis of the CNS (PANCS), 115
 primary CNS vasculitis (PCNSV), 115
 probe selection
 neuro-orbital ultrasound, 301
 transcranial Doppler (TCD) sonography, 142
 PRx. *See* pressure-reactivity index pulsatility indices
 critical care conditions, 259–60
 transcranial Doppler (TCD) sonography, 259–60
 pulse repetition frequency (PRF)
 flow velocity (FV), 5
 insonation depth, 5
 pulsed-wave (PW) Doppler, 1–3
 time-based gating, 5–6
 velocity measurement, grading carotid stenosis, 82–83
- radiologic methods, grading carotid stenosis, 79
 recanalization, acute ischemic stroke (AIS), 175–77
 refill kinetics, intracranial perfusion imaging, 181–84
 reflection, ultrasound, 2
 refraction, ultrasound, 2
 resistance-area product (RAP), cerebral autoregulation (CA), 215–16
 reversed Robin Hood syndrome (RRHS), acute ischemic stroke (AIS), 177–78
 right-to-left shunts (RLS), 206–12
 causes, 206
 chest CT and pulmonary angiography, 206
 contrast transesophageal echocardiography (cTEE), 206
 contrast-enhanced transcranial Doppler sonography (cTCD), 206–12
 detection techniques, 206–7

Index

right-to-left shunts (RLS) (*cont.*)
 diseases other than stroke, 209–10
 evaluation of test results, 209
 imaging tips, 207–8
 prevalence, 206
 questions, 207
 steps of investigation, 208–10
 stroke patients, 210–12
 Valsalva maneuver (VM), 209–10
 RRHS. *See* reversed Robin Hood syndrome
 safety
 intracranial perfusion imaging, 184–85
 neuro-orbital ultrasound, 302
 transcranial Doppler (TCD) sonography, 151
 SCA. *See* superior cerebellar artery
 scattering, ultrasound, 2
 schwannoma (neurinoma), nerve ultrasonography (NUS), 309–10
 screening value, carotid wall imaging, 42
 severe, preocclusive stenosis and pseudo-occlusion, contrast-enhanced carotid ultrasound, 72–73
 sonothrombolysis, 11, 190–93
 acoustic windows, 191
 acute endovascular stroke therapies, 190–91
 anatomy, 191
 criteria for lesions amenable to intervention, 191–93
 future directions, 192–93
 imaging tips, 191
 procedure tips, 191
 questions, 191
 steps of investigation, 191–93
 thrombolysis in brain ischemia (TIBI), 191–93
 SonoVue®, intracranial perfusion imaging, 184–85
 steno-occlusive disease detection, acute ischemic stroke (AIS), 169–73
 stenotic disease, carotid artery. *See* carotid artery stenotic disease
 stereotactic probe-holder for FMD measurement, 50–51
 stroke risk. *See also* acute ischemic stroke (AIS)
 carotid intima–media thickness (cIMT), 40
 carotid plaque (CP), 41
 cervical artery dissection (CAD), 99
 posterior circulation occlusive disease (PCOD), 87–88

vertebrobasilar (VB) occlusive disease, 87–88
 suboccipital insonation, transcranial color-coded duplex sonography (TCCS), 122
 superior cerebellar artery (SCA), transcranial color-coded duplex sonography (TCCS), 137–38
 surrogate markers, atherosclerosis, 41
 synchronized breathing, cerebral autoregulation (CA), 220–21
 syncope, cerebral autoregulation (CA), 224–25
 systematic approach, transcranial Doppler (TCD) sonography, 149
 Takayasu arteritis (TA), 111–12, 114–15
 color-coded duplex sonography (CCDS), 114–15
 incidence, 114
 targeted drug delivery, 12
 TCCS. *See* transcranial color-coded duplex sonography
 TCD. *See* transcranial Doppler sonography
 TCRT. *See* thigh cuffs release test
 TCS. *See* transcranial Doppler (TCD) sonography
 technical aspects
 carotid wall imaging, 36–37
 ultrasound imaging, 36–37
 technical settings
 carotid protocol, 15–16
 common carotid artery (CCA), 17–18
 external carotid artery (ECA), 18–21
 internal carotid artery (ICA), 17–18
 ophthalmic artery (OA) insonation, 20–21
 techniques
 carotid intima–media thickness (cIMT), 58
 carotid plaque (CP), 58–62
 endothelial function testing, 48–49
 vertebral artery (VA), 23, 26–27
 TGA. *See* transient global amnesia
 thigh cuffs release test (TCRT), cerebral autoregulation (CA), 218–19
 thrombolysis in brain ischemia (TIBI)
 acute ischemic stroke (AIS), 172–74
 determination of residual flow, 172–74
 sonothrombolysis, 191–93
 THRT. *See* transient hyperemic response test
 TIBI. *See* thrombolysis in brain ischemia
 Tiecks' model, cerebral autoregulation (CA), 219
 time correlation methods – Mx and PRx, cerebral autoregulation (CA), 222–23
 time-based gating, pulsed-wave (PW) Doppler, 5–6
 tissue harmonic imaging, ultrasound imaging, 8
 tortuosity. *See* elongation, kinking and coiling
 transcranial B-mode sonography (TCS), 288–98
 anatomy, 289–90
 future directions, 297–98
 imaging tips, 290
 neurodegenerative disorders, 292–96
 neuro-intensive care medicine, 297
 questions, 289
 steps of investigation, 290–92
 transcranial color-coded duplex sonography (TCCS), 118–27
 acute ischemic stroke (AIS), 169–71
 anatomical aspects, 118–19
 basilar artery (BA), distal part, 136–37
 circle of Willis (coW), 118–19, 126–27
 examination technique, 119–23
 hemodynamic parameters, 123–26
 insonation planes, 130–31
 internal carotid artery (ICA), 131–33
 intracranial stenosis/occlusion, 154–60, 163
 intracranial venous system, 273
 limitations, 126
 middle cerebral artery (MCA), 133–35
 ophthalmic artery (OA), 133
 posterior cerebral artery (PCA), 135–36
 suboccipital insonation, 122
 superior cerebellar artery (SCA), 137–38
 transnuchal examination, 122
 transorbital examination, 123
 transtemporal examination, 119–22
 transcranial Doppler (TCD) sonography, 118, 140–52, 239–40,
See also functional TCD
 acute ischemic stroke (AIS), 169–72
 anterior cerebral artery (ACA), 143, 144
 anterior communicating artery (ACoA), 144
 applications, 140
 basal cerebral arteries, 145–46

basal cerebral arteries
 identification, 143–45
 basilar artery (BA), 144
 cerebral autoregulation
 (CA), 259–60
 circle of Willis (coW), 140–41, 191
 critical care conditions, 258–61
 documentation, 149–51
 flow velocity (FV), 259–60
 future directions, 151–52
 imaging tips, 141–42, 260–61
 interpretation, normal TCD
 parameters, 145–46
 interpretation, pathological TCD
 patterns, 146–49
 intracranial segment of ICA
 (iICA), 143
 intracranial stenosis/occlusion,
 154–60, 163
 intracranial venous system, 273
 metabolic regulation, 259–60
 microembolic signal (MES)
 detection, 195–201
 middle cerebral artery
 (MCA), 143
 neuromonitoring, critical care
 conditions, 258–61
 open fontanelles (OF) window, 143
 ophthalmic artery (OA), 143
 position of the patient, 142
 posterior cerebral artery (PCA), 144
 posterior communicating artery
 (PCoA), 144
 posterior inferior cerebellar artery
 (PICA), 145
 probe location, 142–43
 probe selection, 142
 pulsatility indices, 259–60
 quality control, 149–51
 questions, 141
 safety, 151
 steps of investigation, 142–45
 submandibular approach (SM), 143
 systematic approach, 149
 transforaminal (TF) or transnuchal
 window, 143
 transorbital (TO) window, 143
 transtemporal (TT)
 window, 142–43
 vertebral artery (VA), 144–45
 transfer function analysis, cerebral
 autoregulation (CA), 221–22
 transient global amnesia (TGA),
 intracranial venous system, 276
 transient hyperemic response test
 (THRT), cerebral autoregulation
 (CA), 220
 transnuchal examination, transcranial
 color-coded duplex sonography
 (TCCS), 122

transorbital examination, transcranial
 color-coded duplex sonography
 (TCCS), 123
 transtemporal examination,
 transcranial color-coded duplex
 sonography (TCCS), 119–22
 traumatic nerve lesions, nerve
 ultrasonography (NUS), 310–11
 UCA (ultrasound contrast agents).
See contrast-enhanced carotid
 ultrasound
 ulnar neuropathy in the elbow region
 (UNE), nerve ultrasonography
 (NUS), 308–9
 ultrasonic methods, grading carotid
 stenosis, 79
 ultrasonic modalities, grading carotid
 stenosis, 82–83
 ultrasound, 1–2
 acoustic boundaries behavior, 2
 amplitude, 1–2
 attenuation, 2–4
 Doppler ultrasound, 4–5
 frequency, 1–2
 high-frequency, 2–4
 low-frequency, 2–4
 reflection, 2
 refraction, 2
 scattering, 2
 speed, 1–3
 wavelength, 1–2
 ultrasound contrast agents, 8–11
 microbubble-based contrast
 agents, 8–10
 non-microbubble-based contrast
 agents, 10–11
 ultrasound contrast agent (UCA).
See contrast-enhanced carotid
 ultrasound
 ultrasound imaging, 6–8
 aliasing phenomenon, 7–8
 B-mode (brightness mode), 7
 color Doppler flow imaging, 7–8
 duplex image, 7
 limitations of ultrasound
 assessment, 23–24, 39, 42
 A-mode (amplitude mode), 6
 vs. MRI, CAD diagnosis, 99–101
 power Doppler mode, 8
 technical aspects, 36–37
 tissue harmonic imaging, 8
 ultrasound technology, 11–12
 blood–brain barrier (BBB)
 opening, 11–12
 brain perfusion imaging, 11
 low mechanical index (MI)
 real-time perfusion scanning, 11
 molecular ultrasound, 12
 sonothrombolysis, 11

targeted drug delivery, 12
 UNE. *See* ulnar neuropathy in the
 elbow region
 unstable plaque definition
 abnormal plaque motion, 66–67
 contrast-enhanced carotid
 ultrasound, 64–68
 echogenicity, 65
 inflammation, 67–68
 microembolic signal (MES)
 detection, 67
 plaque motion analysis, 66–67
 plaque surface, 65–66

VA. *See* vertebral artery
 VAD. *See* vertebral artery dissection
 Valsalva maneuver (VM)
 cerebral autoregulation
 (CA), 219–20
 right-to-left shunts (RLS), 209–10
 varicella zoster virus (VZV), cervical
 artery vasculitides, 115
 vascular permeability, microbubble-
 based contrast agents,
 bioeffects, 10
 vascular risk factor models, 41
 vascularization, plaque,
 contrast-enhanced carotid
 ultrasound, 72–76
 vasomotor reactivity
 (VMR), 228–36
 acetazolamide (Diamox) test, 228–
 29, 231–32
 applications, 233–36
 applications non-related to carotid
 occlusive disease, 235–36
 bilateral carotid occlusive
 disease, 234
 breath-holding or apnea test, 228–
 29, 231, 232
 carotid artery total
 occlusion, 234–35
 carotid occlusive disease,
 233–34
 carotid surgery, 235
 CO₂ inhalation, 228–29, 231, 232
 defining, 228–29
 future directions, 236
 imaging tips, 230
 L-arginine test, 228–29
 leg-cuff method, 228–29, 231, 232
 non-ultrasound techniques for
 measuring, 228–30
 physiology, 230
 questions, 229–30
 steps of investigation, 230–32
 ultrasound techniques for
 measuring, 228–29

VB. *See* vertebrobasilar occlusive
 disease

Index

venous occlusion plethysmography,
 endothelial function
 testing, 48–49
 venous system, intracranial. *See*
 intracranial venous system
 vertebral artery dissection
 (VAD), 106–7
 imaging tips, 106
 intracranial arterial
 dissection, 107
 ultrasound findings, 106–7
 vertebral artery (VA), 23–32
 age-dependent changes, 31
 anatomy, 24–26, 195–97
 catheter intra-arterial angiography
 (CA), 23
 collateral pathways, 26, 165–66
 computed tomographic
 angiography (CTA), 23
 congenital variations, 24–26
 contrast enhanced MRA
 (CE-MRA), 23
 data collecting/storing, 32
 diameter measurement, 30
 documentation, 31
 examination technique, 26–27
 gender-dependent changes, 31
 hemodynamic parameters, 30–31
 hypoplasia, 25–26

importance of ultrasound
 assessment, 23
 limitations of ultrasound
 assessment, 23–24
 magnetic resonance angiography
 (MRA), 23
 non-ultrasound techniques, 23
 questions, 24
 transcranial Doppler (TCD)
 sonography, 144–45
 V1 segment of VA, insonation, 29
 V2 segment of VA,
 examination, 27–28
 V3 segment of VA,
 insonation, 29–30
 V4 or intracranial segment of VA,
 examination, 92–95
 vertebral venous system
 (VVS), 278–85
 anatomy, 278–79
 blood flow velocity (BFV), 282–83
 blood volume flow (BVF), 280–81,
 282–83
 hemodynamics, 282–83
 ultrasonography, 279–82
 vertebrobasilar (VB) occlusive
 disease, 87–96
 anatomy, 88–89
 arteritis, 94–96

blood flow volume measurement, 96
 color-coded duplex sonography
 (CCDS), 89–92
 dissections of the vertebrobasilar
 circulation, 94
 future directions, 96
 imaging tips, 89–90
 microembolic signal (MES)
 detection, 96
 non-ultrasound imaging
 techniques, 88
 posterior circulation occlusive
 disease (PCOD), 87–88
 questions, 88
 subclavian steal
 phenomenon, 93–94
 types, 87–88, 94–96
 V0/V1 segment, 89–91
 V2 segment, 90–92
 V3 segment, 92–93
 V4 segment and basilar
 artery, 92–95
 vertebrobasilar arteritis, 94–96
 VM. *See* Valsalva maneuver
 VMR. *See* vasomotor reactivity
 VVS. *See* vertebral venous system
 VZV. *See* varicella zoster virus
 wavelength, ultrasound, 1–2