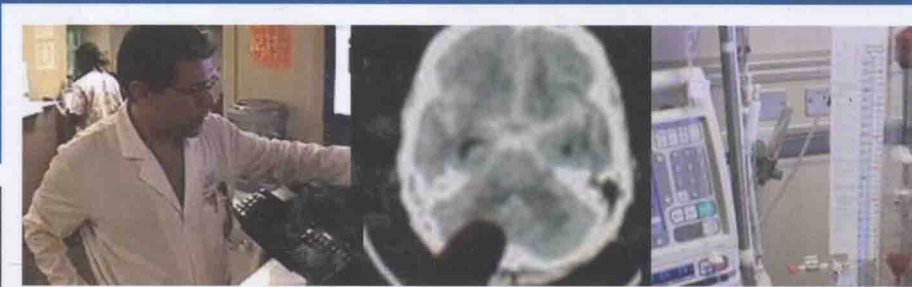


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MONITORING IN NEUROCRITICAL CARE



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Monitoring in Neurocritical Care

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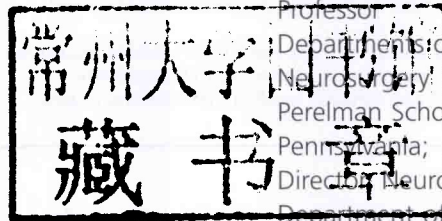
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To the ICU nurses who take care of all our patients

Preface

Neurocritical care has evolved rapidly in the past 10 years. It is a specialty that focuses on the critical care management of patients with catastrophic neurologic diseases, including primary neurologic pathologies such as traumatic brain injury (TBI), ischemic stroke, intracerebral hemorrhage (ICH), subarachnoid hemorrhage (SAH), brain tumors, infection (e.g., HIV, TB, meningitis), spinal cord injury, and acute ascending neuropathies. In addition, neurologic dysfunction occurs in many diverse systemic disorders, including hypoxia (e.g., post cardiac arrest, near drowning), liver dysfunction, electrolyte abnormalities, high altitude sickness, eclampsia, lead intoxication, and malignant hypertension.

There are many reasons why brain injury or damage occurs in patients with neurologic disorders. In particular, multiple experimental and clinical studies have demonstrated a close relationship between variables such as hypoxia, increased intracranial pressure, arterial hypotension, hyperglycemia, fever, and seizures with neurologic outcome, and accumulating evidence suggests that brain damage evolves over time. Minimizing the burden of this delayed, or “secondary,” brain injury, has become the focus of modern neurocritical care. However, despite much research, trials in neuroprotection have largely failed, in part because of their association with prognostic heterogeneity, multiple mechanisms of cellular damage, and a paucity of early mechanistic endpoints. This has led to a realization that strategies of care, or “bundles,” rather than single agents, and approaches that are tailored to individual patient physiology and pathophysiology are necessary to improve outcome.

In daily practice neurointensivists focus on the recognition of subtle changes in the neurologic condition, interactions between the brain and systemic derangements, and brain physiology. The challenge for intensivists today is to identify individuals who are at risk of developing disease or secondary injury, determine disease severity, and distinguish responders from nonresponders to therapy (i.e., individualized and targeted medicine). Monitoring is one tool that may answer these challenges, and it has become central to the management of secondary brain injury and to individualized care. In recent years (interestingly in concert with the evolution of neurocritical care as a distinct specialty), technology developments have resulted in several new monitoring techniques that provide the neurointensivist with information about brain and cellular function. Techniques to better monitor function of the heart, lung, liver, kidney, and blood also have evolved. In addition, when the various techniques are combined (“multimodal monitoring”), a more accurate overall picture of brain function is produced. This approach, along with new computer systems that integrate data at the bedside, and the emerging field of bioinformatics may change the way patients with brain injury are managed in the future.

In the last decade, there have been many advances in neurocritical care monitoring technology and a better

understanding of what information the technology provides. These advances have been chronicled in numerous contributions to the scientific literature, the sheer volume of which makes it difficult for healthcare providers and device engineers to keep up to date with the knowledge necessary to provide the best patient care. In addition, although several textbooks on critical care or head injury briefly discuss monitoring in a chapter or two, there is a paucity of information that summarizes all aspects of neuromonitoring and no textbook that is dedicated to monitoring in neurocritical care.

This book, *Monitoring in Neurocritical Care*, represents a comprehensive review of neuromonitoring. We have designed this textbook to provide the reader with a practical but in-depth reference that describes the scientific basis and rationale for use of a particular monitor, the information it provides, and how this information can be used to manage the neurocritical care patient in an integrated fashion. We have been fortunate to have chapters written by authors from around the world. The contributors are clinicians, engineers, information technology experts, and researchers who have extensive experience in the field, and each has provided an excellent and timely review. We hope that the reader will gain a comprehensive understanding about neuromonitoring and neurocritical care and an insight into existent controversies and potential future management. Its contents will be relevant to neurologists, neurosurgeons, neuroanesthesiologists, neurointensivists, and neuroscience nurses, and will serve as a useful resource to intensivists working in medical and surgical ICUs. For those who are interested in clinical or laboratory research on brain injury in its broad sense, this book will provide many ideas and references and will be a stepping-stone to further progress in understanding a complex problem. The text also will serve as a reference and guide for many engineers, bioengineers, and computer experts who work on medical device and bioinformatics development.

We have divided the book into seven sections. Section I, **Background**, provides information about cerebral metabolism, the principles of neurocritical care, informatics, quality assessment, the role of ICU design and nursing, specific considerations in children, the effects of anesthetic agents on monitors, and a discussion on the relationship between bioethics and monitoring. Section II, **Clinical and Laboratory Assessment**, reviews clinical evaluation, sedation, pain, delirium, outcomes such as neuropsychological and brain death, extracerebral organ systems, laboratory analysis, and the role of biomarkers. Section III, **Electrophysiology**, is devoted to evoked potentials and electroencephalography. Section IV, **Radiology**, discusses the use and integration of various techniques, including computed tomography, xenon-CT, MRI, PET, and SPECT in neurocritical care. Section V, **Cerebral Blood Flow**, is a review of techniques such as neurosonology, laser Doppler flowmetry, thermal diffusion flowmetry, jugular bulb oximetry, and near infrared spectroscopy. Section VI,

Intracranial Monitoring, provides an in-depth review of invasive techniques, including intracranial pressure, brain oxygen, cerebral microdialysis, and brain temperature. The final section, **Computers, Engineering, and the Future**, provides a description of device development, engineering, simulation, telemedicine, robotics, information processing, data acquisition and storage, medical informatics and multimodality monitoring, noninvasive brain monitoring, and a discussion of potential future developments. It is important for the reader to realize that the "ideal brain monitor" does not yet exist and no single monitor will by itself affect outcome. Instead, it is the information provided by a monitor and how we as healthcare providers interpret and apply the information that has the potential to improve outcome and lead to new insights into disease processes.

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Abbreviations

NOTE: Abbreviations may have more than one meaning, depending on their context.

3-H	hypertension, hemodilution, and hypervolemia	ASTM	American Society for Testing and Materials
AACN	American Association of Critical Care Nurses	AT	antithrombin
AAN	American Academy of Neurology	ATC	automatic tube compensation
AARP	American Association of Retired Persons	ATN	acute tubular necrosis
ABA	American Bar Association	ATP	adenosine triphosphate
ABM	acute bacterial meningitis	ATS	American Thoracic Society
ABP	arterial blood pressure	AU	arbitrary units
ACA	anterior cerebral artery	AV	audiovisual
ACE	angiotensin converting enzyme	AVDO₂	arteriovenous difference in oxygen
ACEI/ARBs	angiotensin-converting enzyme inhibitor/ angiotensin-receptor blocker	AVM	arteriovenous malformation
ACGME	Accreditation Council for Graduate Medical Education	BA	basilar artery
AChE	acetylcholinesterase	BAEP	brainstem auditory evoked potential
ACCP	American College of Chest Physicians	BAM	brain acoustic monitor
ACoA	anterior communicating artery	BANN	Bayesian Artificial Neural Network
ACS	abdominal compartment syndrome	BBB	blood-brain barrier
ACT	activated clotting time	BFV	blood flow velocity
ACTH	adrenocorticotrophic hormone	BG	blood glucose
ACV	assist control ventilation	BHI	breath holding index
AD	axial diffusivity	BIS	bispectral index
ADC	apparent diffusion coefficient	BMI	body mass index
ADH	antidiuretic hormone	BMR	basal metabolic rate
ADL	activities of daily living	BOLD	blood oxygen level dependent
ADNI	Alzheimer's Disease Neuroimaging Database	BOOST	Brain Oxygen and Outcome Study in Traumatic Brain Injury
ADP	adenosine diphosphate	BP	blood pressure
ADQI	Acute Dialysis Quality Initiative	BPI	bactericidal permeability-increasing protein
ADR	alpha/delta ratio	BrainIT	brain monitoring with information technology
ADT	admission/discharge/transfer	BSI	bloodstream infection
AED	antiepileptic drug	BSM	bedside monitors
aEEG	amplitude-integrated electroencephalography	BT	brain temperature
AEP	auditory evoked potentials	BTO	balloon test occlusion
AF	atrial fibrillation	BUN	blood urea nitrogen
AG	anion gap	CA	cerebral autoregulation (Chapters 30, 46)
AHA/ASA	American Heart Association/American Stroke Association	CA	cardiac arrest (Chapter 25)
AI	artificial intelligence	CA-BSI	catheter-associated bloodstream infection
AIS	acute ischemic stroke	CAD	coronary artery disease
AKI	acute kidney injury	CAM-ICU	Confusion Assessment Method for the ICU
AKIN	Acute Kidney Injury Network	CAP	College of American Pathologists
ALF	acute liver failure	CAR	cerebral arterial resistance
ALFSG	Acute Liver Failure Study Group	CAS	carotid angioplasty and stenting
ALI	acute lung injury	CASL	continuous arterial spin labeling
AMA	American Medical Association	CBF	cerebral blood flow
AMID	active implantable medical device	CBFV	cerebral blood flow velocity
ANH	artificial nutrition and hydration	CBV	cerebral blood volume
ANN	artificial neural network	CCAT	Computerized Cognitive Assessment Tool
APACHE	Acute Physiology and Chronic Health Evaluation	CCO	continuous cardiac output
aPL	antiphospholipid antibodies	CCT	central conduction time
APN	advanced practice nurse	Ccw	compliance of the chest wall
APP	abdominal perfusion pressure	CDC	Centers for Disease Control and Prevention
aPTT	activated partial thromboplastin time	CDSA	color density spectral array
ARAS	ascending reticular activating system	CEA	carotid endarterectomy
ARC	absolute reticulocyte count	cEEG	continuous electroencephalography
ARDS	acute respiratory distress syndrome	CES	cholesterol emboli syndrome
Ari (or ARI)	autoregulation index	CEUs	continuing education units
ASA	American Society of Anesthesiology	CFM	cerebral function monitoring
aSAH	aneurysmal subarachnoid hemorrhage	C-FMZ	C-flumazenil
ASIA	American Spinal Injury Association	Cho	choline
ASL	arterial spin labeling	CHr	reticulocyte hemoglobin content
		CI	coagulation index

CINMA	critical illness neuromuscular abnormalities	DHHS	Department of Health and Human Services
CIPM	critical illness polyneuromyopathy	DI	diabetes insipidus
CIPNM	critical illness polyneuropathy and myopathy	DIC	disseminated intravascular coagulation
CIRCI	critical illness related corticosteroid insufficiency	DIND	delayed ischemic neurologic deficit
CK	creatinine kinase	DIT	drug-induced thrombocytopenia
Cl	compliance of the lung	DITP	drug-induced immune thrombocytopenia
CLIA 88	Clinical Laboratory Improvements Amendments of 1988	dIVC	inferior vena cava diameter
CLAB	central line-associated bacteraemia	DLCO	diffusing capacity of the lung for carbon monoxide
CLABSI	central line-associated bloodstream infection	DMN	default mode network
CMAP	compound muscle action potentials	DO₂	oxygen delivery
CMO	comfort measures only	DoD	Department of Defense
CMRO₂	cerebral metabolic rate of oxygen	DoE	Department of Energy
CMRGluc	cerebral metabolic rate of glucose	DRG	diagnostic related group
CMS	Centers for Medicare and Medicaid Services	DRS	Disability Rating Scale
CMV	cytomegalovirus	DS	Down syndrome
CNS	central nervous system	DSA	digital subtraction angiography
CO	cardiac output	DSM	Diagnostic and Statistical Manual of Mental Disorders
CO₂	carbon dioxide	DSP	digital signal processing
COGIF	Consensus on Grading Intracranial Flow	DTI	diffusion tensor imaging
COI	cerebral oxygenation index	DUS	duplex ultrasonography
COM	communication	DV	data validation
COMBI	Center for Outcome Measurement in Brain Injury	DVT	deep vein thrombosis
COMPACCS	Committee on Manpower for Pulmonary and Critical Care Societies	DWI	diffusion-weighted imaging
COPD	chronic obstructive pulmonary disease	EAA	excitatory amino acids
COx	cerebral oximetry index	EBM	evidence-based medicine
CPAP	continuous positive airway pressure	EBNP	evidence-based nursing practice
CPOE	computerized order entry	EBP	evidence-based practice
CPP	cerebral perfusion pressure	EC-IC	extracranial to intracranial
CPR	cardiopulmonary resuscitation	ECA	external carotid artery
CPSE	complex partial status epilepticus	ECCO	Essentials of Critical Care Orientation
CPT	current procedural terminology	ECF	extracellular fluid
Cr	creatinine	ECOG	electrocorticogram
CRH	corticotropin-releasing hormone	ED	emergency department
CRM	crew/crisis resource management	EDC	extended differential count
CRMP	collapsin response mediator protein	EDH	epidural hematoma
CRP	C-reactive protein	EDM	esophageal Doppler monitor
CRRT	continuous renal replacement therapy	EDTA	ethylene diamine tetra acetate
CRS	Coma Recovery Scale	EEG	electroencephalography; electroencephalogram
CRS-R	Coma Recovery Scale-Revised	EF	ejection fraction
Crs	compliance of respiratory system	E-GOS	Extended Glasgow Outcome Scale
CSA	cross-sectional area	EHR	electronic health record
CSD	cortical spreading depression	EIT	electrical impedance tomography
CSE	convulsive status epilepticus	EKG	electrocardiogram
CSF	cerebrospinal fluid	ELISA	enzyme-linked immunological sample assay
CSW	cerebral salt wasting	EMG	electromyogram
CT	computed tomography	EMI	electromagnetic interference
CTA	computed tomography angiography	EMR	electronic medical record
CTP	computed tomography perfusion (Chapters 13, 26)	EMS	emergency medical services
CTP	Child-Turcotte-Pugh (Chapter 23)	EN	enteral nutrition
CTT	central conduction time	eNAA	extracellular N-acetyl aspartate
CTV	cerebral venous thrombosis	EOG	electrooculogram
CVC	central venous catheter	EP	evoked potential
CVP	central venous pressure	EPIC	extended prevalence of infection in intensive care
CVR	cerebrovascular resistance	EPL	estimated percent lysis
CVT	cerebral venous thrombosis	EPO	erythropoietin
CVVH	continuous veno-venous hemofiltration	EPOR	erythropoietin receptor
CXR	chest x-ray	ESA	erythropoiesis-stimulating agents
D	diameter of conduit	ESICM	European Society of Intensive Care Medicine
DAI	diffuse axonal injury	ESO	European Stroke Organization
dARI	dynamic autoregulation index	ESRD	end-stage renal disease
DBN	dynamic Bayesian network	ET	endotracheal tube
DBP	diastolic blood pressure	etCO₂	end-tidal carbon dioxide
DBS	deep brain stimulator	ETF	Emerging Technology Fund
DC	decompressive craniectomy	EU	European Union
DCI	delayed cerebral ischemia	EVD	external ventricular drain
DCS	diffuse correlation spectroscopy	EVLWI	extravascular lung water index
DHCA	deep hypothermic circulatory arrest	FA	fractional anisotropy
		FC	Foley catheter

FDA	Food and Drug Administration	HSE	<i>Herpes simplex</i> encephalitis
FD&C	Food, Drug, and Cosmetic Act	HSV	<i>Herpes simplex</i> virus
FDG	fluorodeoxyglucose	HUS	hemolytic uremic syndrome
Fe	iron	HV	hyperventilation
FENa	fractional excretion of sodium	IAP	intra-abdominal pressure
FET	field effect transistor	IBW	ideal body weight
FFF	family, friends, and fools	ICA	internal carotid artery
FFP	fresh frozen plasma	ICAMs	intracellular adhesion molecules
FFT	fast-Fourier transformation	ICE	integrated clinical environment
FIM	Functional Independence Measure	ICG	indocyanine green
FiO₂	inspiratory oxygen fraction	ICH	intracerebral hemorrhage
FLAIR	fluid-attenuated inversion recovery	ICP	intracranial pressure
fmRI	functional magnetic resonance imaging	ICDSC	Intensive Care Delirium Screening Checklist
FNHTR	febrile non-hemolytic transfusion reactions	ICU	intensive care unit
FNN	Foundations of Neuroscience Nursing	IDE	investigational device exemption
FOIA	Freedom of Information Act	IDSA	Infectious Diseases Society of America
FOUR	Full Outline of UnResponsiveness	IEEE	Institute of Electrical and Electronic Engineers
FRBC	fragmented RBC	IEEG	intermittent electroencephalography
FTc	flow time correction	IFNα	interferon- α
F/V	Flotrac-Vigileo	IH	intracranial hypertension
FV	flow velocity	IHD	ischemic heart disease
FVI	flow velocity, left	IIT	intensive insulin therapy
FVL	Factor V Leiden	IJV	internal jugular vein
FVr	flow velocity, right	IL	interleukin
GAAP	generally accepted accounting practices	IMZ	iomazenil
GABA	gamma-aminobutyric acid	IND	investigational new drug
GAP	growth associated protein	INR	international normalized ratio
GB	gigabyte	IOM	Institute of Medicine
GCS	Glasgow Coma Scale	IOP	intraocular pressure
GDP	gross domestic product	IP	intellectual property
GFAP	glial fibrillary acidic protein	IPC	intermittent pneumatic compression
GFR	glomerular filtration rate	IPF	immature platelet fraction
GH	growth hormone	IPS	intensive care unit physician staffing
GHBP	growth-hormone binding protein	IRF	immature reticulocyte fraction
GHRP	GH-releasing peptide	ISF	International Sepsis Forum
GI	gastrointestinal	ISHEN	International Society for Hepatic Encephalopathy and Nitrogen Metabolism
GMDI	Glioma Molecular Diagnostic Initiative	ISO	International Organization for Standardization
GMP	good manufacturing practices	ISS	Injury Severity Score
GN	glomerulonephritis	IT	information technology
GNP	gross national product	ITAA	Information Technology Association of America
GOS	Glasgow Outcome Scale	ITBVI	intrathoracic blood volume index
G-PEDs	generalized periodic epileptiform discharges	IV	intravenous
¹H-MRS	proton magnetic resonance spectroscopy	IVC	inferior vena cava
HAC	hospital-acquired condition	IVIg	intravenous immunoglobulin
HAI	hospital-acquired infection	KIM-1	kidney injury molecular 1
HAP	hospital-acquired pneumonia	LC	liquid chromatography
HbO₂	oxyhemoglobin	LCD	liquid crystal display
HCAP	healthcare-associated pneumonia	LDF	laser Doppler flowmetry
Hct	hematocrit	LDH	lactate dehydrogenase
HE	hepatic encephalopathy	LDUH	low-dose unfractionated heparin
HELLP	hemolytic anemia, elevated liver enzymes, low platelets syndrome	LGIB	lower gastrointestinal bleeding
Hgb	hemoglobin	LGR	lactate:glucose ratio
HHb	deoxyhemoglobin	LIP	lower inflection point
HHCA	Health Care Financing Organization	LMWH	low molecular weight heparin
HHNK	hyperglycemic hyperosmolar nonketotic	lp(a)	lipoprotein (a)
HIE	hypoxic-ischemic encephalopathy	LOC	loss of consciousness
HIPAA	Health Insurance Portability and Accountability Act	LOH	Loop of Henle
HIT	heparin-induced thrombocytopenia	LOI	lactate oxygen index
HiTT	high dose thrombin time	LOS	length of stay
HIV	human immunodeficiency virus	LP	lumbar puncture
HLA	human leukocyte antigens	LPR	lactate:pyruvate ratio
HMG CoA	3-hydroxy-3-methylglutaryl coenzyme A	LUS	lung ultrasound
HMS	Haemostasis Management System	LV	left ventricle
HPA	hypothalamic-pituitary axis	LVEDA	left ventricular end-diastolic area
HPS	human patient stimulator	LVEDV	left ventricular end-diastolic volume
HR	heart rate	MA	maximum amplitude
HRS	hepatorenal syndrome	MAC	mid arm circumference (Chapter 14)

xviii Abbreviations

MAC	minimum alveolar concentration (Chapter 9)	NiCO	noninvasive cardiac output
MAP	mean arterial pressure	NICU	neurointensive care unit
MAP2	microtubule-associate protein type 2	NIH	National Institutes of Health
MB	megabyte	NIHSS	National Institutes of Health Stroke Scale
MBP	myelin basic protein	NINDS	National Institute of Neurological Disease and Stroke
MBs	microbubbles	NIRS	near infrared spectroscopy
MCA	middle cerebral artery	NMDA	N-methyl-D-aspartic
MCHC	mean corpuscular hemoglobin concentration	NNIS	National Nosocomial Infections Surveillance
MCI	mild cognitive impairment	NO	nitric oxide
MCMC	Monte Carlo Markov Chain	NOS	nitric oxide synthase
MCS	minimally conscious state	NOx	nitric oxide metabolite
MCV	mean corpuscular volume	NPH	normal pressure hydrocephalus
MCVr	reticulocyte volume	NPV	negative predictive value
MD	mean diffusion (Chapter 28)	NRBC	nucleated red blood cell
MD	microdialysis (Chapters 36, 48)	NRCPR	National Registry of Cardiopulmonary Resuscitation
MDCT	multidetector computed tomography	NRI	Nutritional Risk Index
MDPnP	Medical Device Plug and Play	NSAID	nonsteroidal anti-inflammatory drug
MDS	myelodysplastic syndrome	NSE	neuron-specific enolase
MEE	measured energy expenditure	NSF	National Science Foundation (Chapter 38)
MEMS	micro electro-mechanical system	NSF	nephrogenic systemic fibrosis (Chapter 22)
MEP	motor evoked potential	NTIS	nonthyroidal illness syndrome
MES	microembolic signal	NTP	Network Time Protocol
MeSH	medical subject heading	OAST	Optimizing Analysis of Stroke Trials
MI	microcirculatory flow index	OEF	oxygen extraction fraction
mGy	milli-Gray	OGR	oxygen-glucose ratio
MI	Maastricht Index (Chapter 14)	ONS	optic nerve sheath
MI	myocardial infarction (Chapter 15)	OPS	orthogonal polarizing spectral
MIB	Medical Information Bus	OR	operating room
MICU	medical intensive care unit	P4P	pay-for-performance
MIPS	maximum intensity projections	PA	pulmonary artery
MMM	multi modality monitor	PAC	pulmonary artery catheter
MMP	matrix metalloproteinases	PaCO₂	arterial carbon dioxide tension
MMPF	multimodal pressure-flow	PACS	picture archiving and communication system
MMSE	Mini-Mental Status Examination	PAD	pulmonary artery diastolic
MOANS	Mayo's Older Americans Normative Studies	PAGE	polyacrylamide gel electrophoresis
MOCA	Montreal Cognitive Assessment	PAI	plasminogen activator inhibitor
MODS	Multiple Organ Dysfunction Syndrome	Palv	alveolar pressure
MPAI	Mayo Portland Adaptability Inventory	PaO₂	arterial oxygen tension
MPM	Mortality Probability Model	PAOP	pulmonary artery occlusion pressure
MPV	mean platelet volume	PAP	pulmonary pressures
MR	magnetic resonance	PAR	pressure autoregulation
MRA	magnetic resonance angiography	PAS	pulmonary artery systolic
MRI	magnetic resonance imaging	PASL	pulsed arterial spin labeling
MRP	magnetic resonance perfusion	PAV	percent alpha variability
MRS	magnetic resonance spectroscopy	PAV+	proportional assist ventilation
mRS	modified Rankin Scale	Paw	airway pressures
MRSA	methicillin resistant <i>Staphylococcus aureus</i>	P_{btO₂}	brain tissue oxygen tension
MS	mass spectrometry	PCA	posterior cerebral artery
mSv	milli-Sieverts	pCAM-ICU	Pediatric Confusion Assessment Method for Intensive Care Unit
MTT	mean transit time	PCI	percutaneous coronary interventions
Mx	autoregulation	PCM	pulse contour method
NAA	N-acetyl aspartate	PCR	polymerase chain reaction
NADH	nicotinamide adenine dinucleotide	PCT	proximal convoluted tubule
NAG	N-acetyl-glucosaminidase	PCWP	pulmonary capillary wedge pressure
NBH	normobaric hyperoxia	PDSA	Plan-Do-Study-Act
nCPPI	noninvasive cerebral perfusion pressure, left	PE	pulmonary embolism
nCCPr	noninvasive cerebral perfusion pressure, right	PED	periodic epileptiform discharges
NCCU	neurocritical care unit	PEEP	positive end-expiratory pressure
NCS	nonconvulsive seizures	PEEPi	intrinsic positive end-expiratory pressure
NCSE	nonconvulsive status epilepticus	Pes	esophageal pressure
NEMS	nano electro-mechanical system	PET	positron emission tomography
NFH	neurofilament heavy chain	PF4	platelet factor 4
NFL	neurofilament light chain	PI	pulsatility index
NFM	neurofilament middle chain	PICARD	Program to Improve Care in Acute Renal Disease
NGAL	neutrophil gelatinase-associated lipocalin	PICC	peripherally inserted central catheter
NHSN	National Healthcare Safety Network	PID	peri-infarct depolarizations
NIBP	noninvasive blood pressure	PICU	pediatric intensive care unit
NICE	National Institute for Clinical Excellence		

PILOT	Pediatric Intensity Level of Therapy	rTEG	rapid thromboelastography
PIM	Pediatric Index of Mortality	rtPA	recombinant tissue plasminogen activator
Pip	peak inspiratory pressure	RTS	Revised Trauma Score
PI	transpulmonary pressure	RTV silicone	room temperature vulcanization silicone
PLED	periodic lateralized epileptiform discharge	RV	right ventricle
Pleth-HR	heart rate from oxygen saturation monitor	SAH	subarachnoid hemorrhage
PMA	premarket approval	SaO₂	arterial oxygen saturation
PN	parenteral nutrition	SAPS	Simplified Acute Physiology Score
PO₂	partial pressure of oxygen	SAS	Riker Sedation-Agitation Scale
POC	point of care	SATs	spontaneous awakening trial
PoCoA	posterior communicating artery	SBDP	spectrin breakdown degradation product
POCT	point of care testing	SBI	secondary brain insults
Pplat	plateau pressure	SBIR	Small Business Innovative Research
PPV	pulse pressure variation	SBP	systolic blood pressure
PRAM	pressure recording analytical method	SBP 120	spectrin breakdown products
PRBC	packed red blood cell	SBTs	spontaneous breathing trials
PRESS	posterior reversible leukoencephalopathy syndrome	SC	serum creatinine
PRx	cerebrovascular pressure reactivity index	SCAT	Standardized Concussion Assessment Tool
PSV	pressure support ventilation	SCCM	Society of Critical Care Medicine
PT	prothrombin time	SCI	spinal cord injury
PT/INR	prothrombin time/international normative ratio	SCM	sternocleidomastoid muscle
PTS	Pediatric Trauma Score	SCUF	slow continuous ultrafiltration
PTSD	post-traumatic stress disorder	ScVO₂	oxygen saturation in superior vena cava (Chapters 19, 40)
PTT	partial thromboplastin time	ScvO₂	mixed venous oxygen saturation (Chapter 23)
PVD	patient-ventilator dyssynchrony	SDE	subdural empyema
PVI	pressure-volume index	SDF	sidestream dark field
PvO₂	oxygen partial pressure in venous blood	SDH	subdural hematoma
PVS	persistent vegetative state	SE	status epilepticus
PWI	perfusion-weighted imaging	SF	short form
QFD	Quality Functional Deployment	SIADH	syndrome of inappropriate antidiuretic hormone
QI	quality initiatives	sICH	spontaneous intracerebral hemorrhage
qMRA	quantitative magnetic resonance angiography	SIMV	Synchronized Intermittent Mechanical Ventilation
QODD	quality of dying and death	SIP	Sickness Impact Profile
QOL	quality of life	SIRS	systemic inflammatory response syndrome
QUASAR	quantitative STAR labeling of arterial regions	SjvO₂	jugular venous oxygen saturation
RA	right atrium	SLE	systemic lupus erythematosus
RAAS	renin-angiotensin-II-aldosterone system	SLT	scanning laser tomography
RAI	relative adrenal insufficiency	SMBG	self-monitoring blood glucose
RAIDs	redundant arrays of independent disks	SMR	standardized mortality ratio
RALS	remote automated laboratory system	SNAP	superlattice nano wire pattern transfer
RAP	cerebrospinal compensatory reserve	SOFA	Sequential Organ Failure Assessment
RASS	Richmond Agitation-Sedation Scale	SPECT	single photon emission computed tomography
RBC	red blood cell	SpO₂	oxygen saturation
RBCT	red blood cell transfusion	SR	suppression ratio
RC	reticulocyte count	SSC	Surviving Sepsis Campaign
rCBF	regional cerebral blood flow	SSEP	somatosensory evoked potential
RCM	radiocontrast media	STC	shock trauma center
RCT	randomized clinical trial	StcO₂	transcranial oxygen saturation
RDW	red cell distribution width	StO₂	tissue oxygen saturation
REE	resting energy expenditure	STTR	Small Business Technology Transfer
REG	rheoencephalography	SV	stroke volume
RF	radio frequency	SVC	superior vena cava
rhuEPO	recombinant human erythropoietin	SVM	support vector machine
Ri	inspiratory resistance	SVO₂	venous oxygen saturation
RN	registered nurse	SVV	stroke volume variability
ROI	regions of interest	SWI	susceptibility-weighted imaging
ROSC	return of spontaneous circulation	T	body temperature (Chapters 45, 48)
ROTEM	rotational thromboelastometry	T	translational (Chapter 6)
RPT	robotic telepresence	T3	triiodothyronine
RQ	respiratory quotient	T4	thyroxine
RR	respiratory rate	TBI	traumatic brain injury
RRT	renal replacement therapy	Tc99m-ECD	technetium-99m-ethylcysteinate dimer
RS	Ramsay Sedation Scale	Tc99m-HMPAO	technetium-99m-hexamethylpropyleneamine oxide
RSE	refractory status epilepticus	TCCS	transcranial color-coded duplex sonography
rSO₂	regional cerebral oxygen saturation	TCD	transcranial Doppler
rSO₂C	regional cerebral tissue oxygenation	TcE	transcranial electrical (stimulation)
rSO₂R	regional renal tissue oxygenation	TcMEP	transcranial electrical motor evoked potential
rSO₂S	regional splanchnic tissue oxygenation	TcMMEP	transcranial magnetic motor evoked potential

TDF	thermal diffusion flowmetry	UO	urine output
TDM	time division multiplex	US	ultrasound
TEE	transesophageal echocardiography	UTI	urinary tract infection
TEG	thromboelastography	UUN	urine urea nitrogen
TF	tissue factor	VA	vertebral artery
TH	therapeutic hypothermia	VALI	ventilator-associated lung injury
THb	total hemoglobin	VAP	ventilator-associated pneumonia
THR	transient hyperemic response	VASO	vascular space occupancy
THx	total hemoglobin reactivity	VC	venture capital (Chapter 38)
TI	thermal index	VC	vital capacity (Chapter 20)
TIBC	total iron binding capacity	VCAM-1	vascular cell adhesion molecule-1
TIBI	thrombolysis in brain ischemia	VE	expired minute volume
TIL	Therapeutic Intensity Level	VEEG	video electroencephalography
TLC	total lymphocyte count	VEGF	vascular endothelial cell growth factor
TNF	tumor necrosis factor	VEP	visual evoked potentials
TOI	tissue oxygen index	V_I	inspiratory flow
TOR	brain tissue oxygen response	VILI	ventilator-induced lung injury
tPA	tissue plasminogen activator	VKA	vitamin K antagonist
TPL	transplant	VMRr	vasomotor reactivity
TR	tricuspid regurgitation	VO	virtual organization
TRALI	transfusion-related acute lung injury	VO₂	oxygen consumption
TRC	tanned red cell	VPR	volume-pressure response
TRH	thyrotropin-releasing hormone	VRE	vancomycin-resistant enterococcus
TRICC	transfusion requirements in critical care	VS	vegetative state
TRISS	Trauma Injury Severity Score	VSP	vasospasm
TS	test standard	VT	tidal volume
TSF	triceps skinfold thickness	VTE	venous thromboembolism
TSH	thyroid stimulating hormone	VTI	velocity time integral
T-tau	total tau	vWD	von Willebrand's disease
TTE	transthoracic echocardiography	vWF	von Willebrand multimers
TTP	thrombotic thrombocytopenic purpura	WBC	white blood cell
TV	tidal volume	WDM	wavelength division multiplex
UCH	ubiquitin C-terminal hydrolase	WFNS	World Federation of Neurological Societies
UFH	unfractionated heparin	WHO	World Health Organization
UGIB	upper gastrointestinal bleeding	WNV	West Nile virus
UIP	upper inflection point	WNVE	West Nile virus encephalitis
UMLS	Unified Medical Language System	Xe-CT	xenon-enhanced computed tomography
UNa	urinary sodium concentration		