Anesthesia and Perioperative Care of the High-Risk Patient
Anesthesia and Perioperative Care of the High-Risk Patient

Third Edition

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Foreword

The current practice of anesthesia, pain, perioperative, and critical care medicine is increasingly characterized by high-risk patients with advanced age and co-morbidity for an ever-growing spectrum of surgical interventions in and out of the operating rooms. Anesthesia management has advanced with preoperative admission screening and tests, cardiac medications guidelines, predictive risk assessment and optimization; intraoperative monitoring, safer anesthetic agents, regional anesthesia techniques, and blood management; postoperative pain and fast-track recovery management. These perioperative developments and team-based care have contributed to the remarkable safety and very low mortality and morbidity rate in modern anesthesia, despite a higher prevalence of high-risk patients.

This comprehensive, concise, and practical book edited by Dr. Ian McConachie is updated from the Second Edition and provides a useful guide to the anesthesia management and postoperative care of high-risk adult patients undergoing elective and emergency surgery. This book provides a succinct, problem-oriented source of practical information, based on current best evidence and the content-expert experience of leading clinicians. The outstanding and unique contributors selected by Dr. McConachie from both sides of the Atlantic have presented a full spectrum of preoperative, intraoperative, and postoperative management of high-risk surgical patients undergoing anesthesia care; in particular, patients with specific disease have been highlighted in individual chapters.

All practitioners will benefit from refreshing and acquiring new knowledge of the principles and advanced perioperative anesthesia management presented in these chapters with the goal of improving the care of high-risk surgical patients.

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Preface to the third edition

This text:

- is aimed primarily at trainees in Anesthesia although more experienced practitioners may find it useful as a refresher in recent concepts and advances. A basic knowledge of physiology, pharmacology, and anesthesia is assumed.
- may be a useful aide memoire for postgraduate examinations in anesthesia.
- exclusively discusses adult anesthesia. Pediatric and neonatal anesthesia is outside the scope of this text.
- aims to provide practical information on the management of high-risk patients presenting for surgery as well as sufficient background information to enable understanding of the principles and rationale behind their anesthetic and perioperative management. We hope it will prove useful but we would emphasize that this, or any other book, is no substitute for experienced supervision, support, and training.
- is not a substitute for the major anesthetic texts but concentrates on principles of management of the most challenging anesthetic cases.
- has a slightly changed title in this third edition, to emphasize the importance of a coordinated approach to the high-risk surgical patient in the perioperative period and to highlight the role of the anesthetist as perioperative physician. We aim to “bridge the gap” between the operating room and the intensive care unit and to provide guidance to manage patients in the perioperative period in line with modern concepts of critical care.
- emphasizes cardiovascular risk and cardiac disease and its management as these undoubtedly are the most important aspects of perioperative anesthetic risk.
- incorporates a selective choice of topics but should appeal and be useful to the majority of practitioners. Important information not readily available in similar texts is also included.
- is designed so that the format provides easy access to information presented in a concise manner. We have tried to eliminate all superfluous material. Selected important or controversial references are presented. The styles of the chapters vary. This is deliberate. Some relate more to basic principles, physiology, pharmacology, etc. – bookwork. Others are more practical in nature, discussing the principles of anesthetic techniques for certain high-risk situations.
- was written by authors who are all experienced practitioners working with high-risk patients presenting for both elective and emergency surgery. The authors are committed to providing a high level of perioperative care of patients undergoing anesthesia. We make no apologies for repetition of important principles and facts – a second perspective on a subject is often useful.
- incorporates contributions from a multinational team, enlisted by the editor from institutions on both sides of the Atlantic. The contributors are active in both practice and training. The aim therefore has been to produce a text of international relevance.
- builds, in this third edition, on the success of the second and contains several new chapters as well as revisions of older chapters.
by way of disclosure, includes many drugs discussed and many trials reported and
discussed that involve use of drugs in "off label" situations. Use of drugs in such
situations is at the discretion of individual physicians after full evaluation of the
circumstances at that time. Similarly, dosages presented in this text represent those
commonly found in the literature but physicians should always seek guidance from
appropriate pharmaceutical literature.

Ian McConachie
Abbreviations

AAA abdominal aortic aneurysm
AAGBI Association of Anaesthetists of Great Britain and Ireland
ABG arterial blood gases
ABW actual body weight
ACC American College of Cardiology
ACCF American College of Cardiology Foundation
ACCP American College of Chest Physicians
ACE angiotensin-converting enzyme
ACRM Anesthesia Crisis Resource Management
aCS acute coronary syndrome
ACS American College of Surgeons
ACS NSQIP American College of Surgeons National Surgical Quality Improvement Program
ACTH adrenocorticotropic hormone
ADH antidiuretic hormone
ADHD attention deficit hyperactivity disorder
ADL activities of daily living
ADP adenosine diphosphate
ADQI acute dialysis quality initiative
AF atrial fibrillation
AHA American Heart Association
AHI Apnea-Hypopnea Index
AHRQ Agency for Healthcare Research and Quality
AI aortic incompetence
AICD automated implantable cardiac defibrillator
AIMS Anaesthetic Incident Monitoring Study
AKI acute kidney injury
AKIN acute kidney injury network
AL anastomotic leak
ALI acute lung injury
ANH acute normovolemic hemodilution
APACHE acute physiology and chronic health evaluation
APS Acute Pain Service
APR anticoagulant platelet response
APT antiplatelet therapy
aPTT activated partial thromboplastin time
AR aortic regurgitation
ARA angiotensin receptor antagonist
ARB angiotensin receptor blocking
ARDS acute respiratory distress syndrome
AS aortic stenosis
ASA American Society of Anesthesiologists
ASRA American Society of Regional Anesthesia
ATN acute tubular necrosis
ATP adenosine triphosphate
AUC area under the curve
AV arteriovenous
-AV atrioventricular
AVF arteriovenous fistula
AVG arteriovenous graft
AVPU alert, voice, pain, unresponsive
AVR aortic valve replacement
AWS alcohol withdrawal syndrome
BARI Bypass Angioplasty Revascularization Investigation
BART Blood Conservation Using Antifibrinolytics in a Randomized Trial
BIPAP bilevel positive airway pressure
BIS bispectral index score
BMI Body Mass Index
BMS bare-metal stent
BNP brain natriuretic peptide
BPI bactericidal permeability increasing (protein)
BPIInv Brief Pain Inventory
BRAN (Benefits, Risks, Alternatives, Nothing)
BUN blood urea nitrogen
CABG coronary artery bypass grafting
CCB calcium channel blockers
CaO2 arterial oxygen content
CAD coronary artery disease
CAM Confusion Assessment Method
Carp Coronary Artery Revascularization Prophylaxis trial
CAS carotid artery stenting
<table>
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<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>CASE</td>
<td>Comprehensive Anaesthesia Simulation Environment system</td>
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<tr>
<td>CASS</td>
<td>Coronary Artery Surgery Study</td>
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<td>CBF</td>
<td>cerebral blood flow</td>
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<tr>
<td>CC</td>
<td>creatinine clearance</td>
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<td>CCF</td>
<td>congestive cardiac failure</td>
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<td>CCOT</td>
<td>critical care outreach team</td>
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<tr>
<td>CCRT</td>
<td>continuous renal replacement therapy</td>
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<tr>
<td>CCTA</td>
<td>coronary computed tomography angiography</td>
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<tr>
<td>CEA</td>
<td>carotid endarterectomy</td>
</tr>
<tr>
<td>CEPOD</td>
<td>Confidential Enquiry into Peri-Operative Deaths</td>
</tr>
<tr>
<td>CG</td>
<td>control group</td>
</tr>
<tr>
<td>CHD</td>
<td>congenital heart disease</td>
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<td>CHF</td>
<td>congestive heart failure</td>
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<tr>
<td>CI</td>
<td>cardiac index</td>
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<tr>
<td>CI95</td>
<td>95% confidence interval</td>
</tr>
<tr>
<td>CIN</td>
<td>contrast-induced nephropathy</td>
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<tr>
<td>CKD</td>
<td>chronic kidney disease</td>
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<td>CMR</td>
<td>cardiac magnetic resonance</td>
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<td>CMV</td>
<td>cytomegalovirus</td>
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<tr>
<td>CNA</td>
<td>central neuraxial analgesia</td>
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<tr>
<td>CNI</td>
<td>calcinurin inhibitor</td>
</tr>
<tr>
<td>CNS</td>
<td>central nervous system</td>
</tr>
<tr>
<td>CNST</td>
<td>Clinical Negligence Scheme for Trusts</td>
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<tr>
<td>CO</td>
<td>cardiac output</td>
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<td>COETT</td>
<td>cuffed oral endotracheal tube</td>
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<td>COPD</td>
<td>chronic obstructive pulmonary disease</td>
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<td>COX</td>
<td>cyclooxygenase</td>
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<tr>
<td>CP</td>
<td>cricoid pressure</td>
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<td>CPAP</td>
<td>continuous positive airway pressure</td>
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<td>CPB</td>
<td>cardiopulmonary bypass</td>
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<td>CPET</td>
<td>cardiopulmonary exercise testing</td>
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<td>CPK</td>
<td>creatine phosphokinase</td>
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<td>CPP</td>
<td>cerebral perfusion pressure</td>
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<td>cardiopulmonary resuscitation</td>
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<td>cardiopulmonary exercise</td>
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<td>Cr</td>
<td>creatinine</td>
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<td>CRI</td>
<td>Cardiac Risk Index</td>
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<td>CRRT</td>
<td>continuous renal replacement therapy</td>
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<td>CRT</td>
<td>cardiac resynchronization therapy</td>
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<td>CSF</td>
<td>cerebrospinal fluid</td>
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<td>CT</td>
<td>computed tomography</td>
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<td>CTA</td>
<td>computed tomographical angiography</td>
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<td>CV</td>
<td>closing volume</td>
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<td>CVA</td>
<td>cardiovascular accident</td>
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<td>CVD</td>
<td>cardiovascular disease</td>
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<td>CvO2</td>
<td>venous oxygen content</td>
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<td>central venous pressure</td>
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<td>DX</td>
<td>chest X-rays</td>
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<td>DAI</td>
<td>diffuse axonal injury</td>
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<td>DAPT</td>
<td>dual antiplatelet therapy</td>
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<td>DASI</td>
<td>Duke Activity Status Index</td>
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<td>DCCT</td>
<td>Diabetes Control and Complications Trial</td>
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<td>DCLB</td>
<td>diasprin cross-linked hemoglobin</td>
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<td>DES</td>
<td>drug-eluting stent</td>
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<tr>
<td>DLCO</td>
<td>diffusion capacity of the lung for carbon monoxide</td>
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<td>DM</td>
<td>diabetes mellitus</td>
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<tr>
<td>DNAR</td>
<td>do not attempt resuscitation</td>
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<td>DNR</td>
<td>do not resuscitate</td>
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<tr>
<td>DO2</td>
<td>oxygen delivery</td>
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<td>DPG</td>
<td>diphosphoglycerate</td>
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<td>DSE</td>
<td>dobutamine stress echocardiography</td>
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<td>DT</td>
<td>delirium tremens</td>
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<td>DTI</td>
<td>direct thrombin inhibitors</td>
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<td>DVD</td>
<td>degenerative valve disease</td>
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<td>deep vein thrombosis</td>
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<td>epidural analgesia</td>
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<td>Epstein–Barr virus</td>
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<td>electrocardiograph</td>
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<td>Eastern Cooperative Oncology Group</td>
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<td>extradural hematoma</td>
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<td>electroencephalography</td>
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<td>EF</td>
<td>ejection fraction</td>
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<td>EG</td>
<td>exercise group</td>
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<tr>
<td>eGFR</td>
<td>estimated glomerular filtration rate</td>
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<td>electromyograph</td>
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<td>EN</td>
<td>enteral nutrition</td>
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<td>erythropoietin</td>
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<td>ER</td>
<td>emergency room</td>
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<td>ERAS</td>
<td>enhanced recovery after surgery</td>
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<td>enhanced recovery protocols</td>
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<td>ERV</td>
<td>expiratory reserve volume</td>
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<tr>
<td>ESA</td>
<td>European Society of Anaesthesiology</td>
</tr>
<tr>
<td>E-SA</td>
<td>erythropoiesis-stimulating agents</td>
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</table>
ESAS Edmonton Symptom Assessment Scale
ESC European Society of Cardiology
ESLD end-stage liver disease
ESRD end-stage renal disease
EuSOS European Surgical Outcomes Study
EWS Early Warning Score
FDA Food and Drug Administration
FDP fibrin degradation products
FEV forced expiratory volume
FFP fresh, frozen plasma
FiO2 inspired oxygen concentration
FOI fiberoptic intubation
FRC functional residual capacity
FVC forced vital capacity
GA general anesthesia/anesthetic
GABA γ-aminobutyric acid
GCS Glasgow Coma Scale
G-CSF granulocyte colony-stimulating factor
GD goal-directed
GDT goal-directed therapy
GFR glomerular filtration rate
GI gastrointestinal
HABR hepatic arterial buffer response
Hb hemoglobin
HBOCs hemoglobin-based oxygen carriers
HCC hepatocellular carcinoma
Hct hematocrit
HDU high-dependency unit
HE hepatic encephalopathy
HF heart failure
HIV human immunodeficiency virus
HMG 3-hydroxy-3-methyl-glutaryl
HOCM hyperthrophic obstructive cardiomyopathy
HPS hepatopulmonary syndrome
HRO high-reliability organization
HRR heart rate reserve
HRS hepatorenal syndrome
HTN hypertension
IABP intra-aortic balloon pump
IADL instrumental activities of daily living
IAP intra-abdominal pressure
IBF intestinal blood flow
IBW ideal body weight
ICD implantable cardioverter-defibrillators
ICP intracranial pressure
ICU intensive care unit
IDDS intrathecal drug delivery system
IE infective endocarditis
IHD ischemic heart disease
IL interleukin
IMT inspiratory muscle training
INR international normalized ratio
IPPV intermittent positive pressure ventilation
ISB interscalene block
ITP intrathoracic pressure
ITS iontophoretic transdermal system
IV intravenous
IVRA intravenous regional analgesia
IYDT if you do not treat
KIM1 kidney injury molecule 1
LAt left atrium
LA local anesthetic
LMA laryngeal mask airway
LoS length of stay
LV left ventricular/ventricle
LVEDP left ventricular end-diastolic pressure
LVEDV left ventricular end-diastolic volume
LVH left ventricular hypertrophy
LVOT left ventricle outflow tract
M3G morphine-3-glucuronide
M6G morphine-6-glucuronide
MAC minimum alveolar concentration
MACE major adverse cardiac events
MAMC mid-arm muscle circumference
MAP mean arterial pressure
MTB massive blood transfusion
MDEA 3,4-methylenedioxylamphetamine
MDMA methylenedioxymethamphetamine
MDPV methylenedioxypyrovalerone
MELD model for end-stage liver disease
MEP motor evoked potentials
mEq milliequivalents
MEQ metabolic equivalent
MERIT Medical Early Response Intervention and Therapy
MET medical emergency team
MEWS Modified Early Warning System
MI myocardial infarction
MMA multimodal analgesia
MMF mycophenolate mofetil
MODS multi-organ dysfunction syndrome
MR mitral regurgitation
MRA magnetic resonance angiogram
MRI magnetic resonance imaging
MS mitral stenosis
mTAL medullary thick ascending part of the loop of Henlé
mTOR mammalian target-of-rapamycin
MUST malnutrition screening tool
MVIR mitral valve replacement
NAC neoadjuvant chemotherapy
NARC neoadjuvant chemoradiotherapy
NASH non-alcoholic steatohepatitis
NCCG Non-Consultant Career Grade
NCEPOD National Confidential Enquiry into Perioperative Deaths
NDMR non-depolarizing muscle relaxants
NEWS National Early Warning System
NG nasogastric
NHS National Health Service
NICE National Institute for Health and Clinical Excellence
NIRS near infrared spectroscopy
NK natural killer (cells)
NMDA N-methyl-D-aspartate
NNH number needed to harm
NNM number needed to monitor
NNT number needed to treat
NO nitric oxide
N2O nitrous oxide
NRI nutritional risk index
NRS numerical rating scale
NRT nicotine replacement therapy
NSAIDs non-steroidal anti-inflammatory drugs
NSCLC non-small cell lung cancer
NT pro-BNP N-terminal pro-brain natriuretic peptide
NYHA New York Heart Association
OCP oral contraceptive pill
ODC oxyhemoglobin dissociation curve
OHS obesity hypoventilation syndrome
OR odds ratio
ORM operating room
OSA obstructive sleep apnea
OSAS obstructive sleep apnea syndrome
PA pulmonary arteries
PAC pulmonary artery catheter
PACU post-anesthesia care unit
PAFC pulmonary artery flotation catheter
PAI plasminogen activator inhibitor
PAOP pulmonary artery occlusion pressure
PAP positive airway pressure
PART patient-at-risk team
PASP pulmonary artery systolic pressure
PBW predicted body weight
PC palliative care
PCA patient-controlled analgesia
PCC prothrombin complex concentrate
PCEA patient-controlled epidural analgesia
PCI percutaneous coronary intervention
pCO₂ arterial carbon dioxide tension/partial pressure of carbon dioxide
PCT proximal convoluted tubule
PCWP pulmonary capillary wedge pressure
PE pulmonary embolism
PEEP positive end expiratory pressure
PEM protein energy malnutrition
PFC perfluorocarbon
PFT pulmonary function test
PHTN pulmonary hypertension
PIP peak inspiratory pressure
PMI perioperative myocardial infarction
PNS peripheral nerve stimulator
pO₂ partial pressure of oxygen/arterial oxygen tension
POC point-of-care
POCD postoperative cognitive dysfunction
POISE Perioperative Ischemic Events Trial
PONV postoperative nausea and vomiting
PORIF perioperative renal insufficiency and failure
POSSUM Physiological and Operative Severity Score for the Enumeration of Mortality and Morbidity
PPC perioperative pulmonary complications
PPO predicted postoperative
PPV pulse pressure variation
PR pulmonary rehabilitation
PSS physiological scoring system
Abbreviations

PT  prothrombin time
PTLD  post-transplant lymphoproliferative disorder
PTT  partial thromboplastin time
PVB  paravertebral block
PVR  pulmonary vascular resistance
QoL  quality of life
RA  regional anesthesia
RAI  right atrium
RAS  renin–angiotensin system
RBCs  red blood cells
RBF  renal blood flow
RCRI  Revised Cardiac Risk Index
RCT  randomized controlled trial
RER  respiratory exchange ratio
rFVIIa  recombinant activated factor
RHD  rheumatic heart disease
RIFLE  risk, injury, failure, loss, and end-stage kidney disease
RM  recruitment maneuver
ROC  receiver operating characteristic
ROS  reactive oxygen species
RPP  renal perfusion pressure
RR  relative ratio
RRS  rapid response system
RRT  rapid response teams
RRTh  renal replacement therapy
RSII  rapid sequence induction and intubation
RV  right ventricular/ventricle
RVol  residual volume
RVR  renal vascular resistance
SABA  short-acting β-agonist
SAH  subarachnoid hemorrhage
SAM  systolic anterior motion
SAPS  simplified acute physiology score
SaO₂  arterial oxygen saturation
SCAI  Society for Cardiovascular Angiography Interventions
SCC  squamous cell carcinoma
SCI  spinal cord injury
SCLC  small cell lung cancer
SCPP  spinal cord perfusion pressure
SGr  serum creatinine
ScvO₂  central venous blood oxygen saturation
SDH  subdural hematoma
SDM  substitute decision makers
SEP  somatosensory evoked potentials
SGA  subjective global assessment
SGD  upraglottic airway device
SIADH  syndrome of inappropriate antidiuretic hormone
SIRS  systemic inflammatory response syndrome
SLIP  surgical lung injury prediction
S-MPM  Surgical Mortality Probability Model
SpA  spinal anesthesia
SP  stump pressure
SpO₂  oxygen saturation via pulse oximetry
SSI  surgical site infection
SSRI  selective serotonin reuptake inhibitor
ST  stent thrombosis
SV  stroke volume
SVC  superior vena cava
SVI  stroke volume index
SVO₂  mixed venous oxyhemoglobin saturation
SVR  systemic vascular resistance
TAA  thoracic aorta aneurysm
TACE  transarterial chemoembolization
TAPB  transversus abdominis plane block
TBI  traumatic brain injury
TCA  tricarboxylic acid
TCD  transcranial Doppler
TEA  thoracic epidural analgesia
TEE  transesophageal echocardiography
TEG  thromboelastography
TEVAR  thoracic endovascular aortic repair
TF  tissue factor
TGF  tubuloglomerular feedback
THC  tetrahydrocannabinol
ThRCRI  Thoracic Revised Cardiac Risk Index
TIMI  thrombosis in myocardial infarction
TIPS  transjugular intrahepatic portosystemic shunt
TIVA  total intravenous anesthesia
TLC  total lung capacity
TNF  tumor necrosis factor
tPA  tissue plasminogen activator
<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Description</th>
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<tbody>
<tr>
<td>TPN</td>
<td>total parenteral nutrition</td>
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<tr>
<td>TRALI</td>
<td>transfusion-related acute lung injury</td>
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<tr>
<td>TRBF</td>
<td>total renal blood flow</td>
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<tr>
<td>TRICC</td>
<td>Transfusion Requirements in Critical Care</td>
</tr>
<tr>
<td>TRIM</td>
<td>transfusion-related immune modulation</td>
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<tr>
<td>TSF</td>
<td>triple skin fold thickness</td>
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<tr>
<td>TXA</td>
<td>tranexamic acid</td>
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<tr>
<td>UO</td>
<td>urine output</td>
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<tr>
<td>US</td>
<td>ultrasound</td>
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<tr>
<td>VAD</td>
<td>ventricular assist device</td>
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<tr>
<td>VAE</td>
<td>venous air embolism</td>
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<tr>
<td>VC</td>
<td>vital capacity</td>
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<tr>
<td>vCJD</td>
<td>human variant Creutzfeldt-Jacob disease</td>
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<tr>
<td>VEGF</td>
<td>vascular endothelial growth factor</td>
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<tr>
<td>VHD</td>
<td>valvular heart disease</td>
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<tr>
<td>VILI</td>
<td>ventilator-induced lung injury</td>
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<tr>
<td>VIP</td>
<td>ventilation, infusion, and perfusion</td>
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<tr>
<td>VO₂</td>
<td>oxygen consumption</td>
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<tr>
<td>VRE</td>
<td>vancomycin-resistant enterococcus</td>
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<tr>
<td>VSAQ</td>
<td>Veterans Specific Activity Questionnaire</td>
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<tr>
<td>VTE</td>
<td>venous thromboembolism/thromboembolic disease</td>
</tr>
<tr>
<td>WFNS</td>
<td>World Federation of Neurosurgical Societies</td>
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<tr>
<td>WHO</td>
<td>World Health Organization</td>
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