Anesthesia and Perioperative Care of the High-Risk Patient

Third Edition

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Edited by

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Every effort has been made in preparing this book to provide accurate and up-to-date information which is in accord with accepted standards and practice at the time of publication. Although case histories are drawn from actual cases, every effort has been made to disguise the identities of the individuals involved. Nevertheless, the authors, editors and publishers can make no warranties that the information contained herein is totally free from error, not least because clinical standards are constantly changing through research and regulation. The authors, editors and publishers therefore disclaim all liability for direct or consequential damages resulting from the use of material contained in this book. Readers are strongly advised to pay careful attention to information provided by the manufacturer of any drugs or equipment that they plan to use.

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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 comorbidity 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, and 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 diseases 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
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
A-V 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)
BPInv Brief Pain Inventory
BRAN (Benefits, Risks, Alternatives, Nothing)
BUN blood urea nitrogen
CABG coronary artery bypass grafting
CCB calcium channel blockers
CaO_2 arterial oxygen content
CAD coronary artery disease
CAM Confusion Assessment Method
CARP Coronary Artery Revascularization Prophylaxis trial
CAS carotid artery stenting

CASE Comprehensive Anaesthesia Simulation Environment system
CASS Coronary Artery Surgery Study
CBF cerebral blood flow
CC creatinine clearance
CCF congestive cardiac failure
CCOT critical care outreach team
CCRT continuous renal replacement therapy
CCTA coronary computed tomography angiography
CEA carotid endarterectomy
CEPOD Confidential Enquiry into Peri-Operative Deaths
CG control group
CHD congenital heart disease
CHF congestive heart failure
CI cardiac index
CI_{95} 95% confidence interval
CIN contrast-induced nephropathy
CKD chronic kidney disease
CMR cardiac magnetic resonance
CMV cytomegalovirus
CNA central neuraxial analgesia
CNI calcinurin inhibitor
CNS central nervous system
CNST Clinical Negligence Scheme for Trusts
CO cardiac ouput
COETT cuffed oral endotracheal tube
COPD chronic obstructive pulmonary disease
COX cyclooxygenase
CP cricoid pressure
CPAP continuous positive airway pressure
CPB cardiopulmonary bypass
CPET cardiopulmonary exercise testing
CPK creatine phosphokinase
CPP cerebral perfusion pressure
CPR cardiopulmonary resuscitation
CPX cardiopulmonary exercise
Cr creatinine
CRI Cardiac Risk Index
CRRT continuous renal replacement therapy
CRT cardiac resynchronization therapy
CSF cerebrospinal fluid
CT computed tomography
CTA computed tomographical angiography
CV closing volume
CVA cardiovascular accident
CVD cardiovascular disease
CvO_2 venous oxygen content
CVP central venous pressure
CXRs chest X-rays
DAI diffuse axonal injury
DAPT dual antiplatelet therapy
DASI Duke Activity Status Index
DCCT Diabetes Control and Complications Trial
DCLB diasprin cross-linked hemoglobin
DES drug-eluting stent
DLCO diffusion capacity of the lung for carbon monoxide
DM diabetes mellitus
DNAR do not attempt resuscitation
DNR do not resuscitate
DO_2 oxygen delivery
DPG diphosphoglycerate
DSE dobutamine stress echocardiography
DT delirium tremens
DTI direct thrombin inhibitors
DVD degenerative valve disease
DVT deep vein thrombosis
EA epidural analgesia
EBV Epstein–Barr virus
ECG electrocardiograph
ECOG Eastern Cooperative Oncology Group
EDH extradural hematoma
EEG electroecephalography
EF ejection fraction
EG exercise group
eGFR estimated glomerular filtration rate
EMG electromyograph
EN enteral nutrition
EPO erythropoietin
ER emergency room
ERAS enhanced recovery after surgery
ERP enhanced recovery protocols
ERV expiratory reserve volume
ESA European Society of Anaesthesiology
E-SA erythropoiesis-stimulating agents

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
FiO_2 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
MBT massive blood transfusion
MDEA 3,4-methylenedioxyethamphetamine
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
MVR 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
N_2O 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
pCO_2 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
pO_2 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

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
RAt 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
RRTs 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
SaO_2 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
SCr serum creatinine
$ScvO_2$ 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
SpO_2 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
SVO_2 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

TPN total parenteral nutrition
TRALI transfusion-related acute lung injury
TRBF total renal blood flow
TRICC Transfusion Requirements in Critical Care
TRIM transfusion-related immune modulation
TSF triple skin fold thickness
TXA tranexamic acid
UO urine output
US ultrasound
VAD ventricular assist device
VAE venous air embolism
VC vital capacity
vCJD human variant Creutzfeldt–Jacob disease
VEGF vascular endothelial growth factor
VHD valvular heart disease
VILI ventilator-induced lung injury
VIP ventilation, infusion, and perfusion
VO_2 oxygen consumption
VRE vancomycin-resistant enterococcus
VSAQ Veterans Specific Activity Questionnaire
VTE venous thromboembolism/ thromboembolic disease
WFNS World Federation of Neurosurgical Societies
WHO World Health Organization