Basic Physiology for Anaesthetists

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DC:
Book-writing is rather like parenthood: one cannot fully anticipate the time commitment required. For their (generally) unwavering support, I would like to thank my wife, Sally, and my girls, Georgie and Eliza.

CH:
In memoriam absentium, in salutem praesentium: I would like to thank my friends and teachers, Charles Michel, Richard Adrian, Sir David Weatherall and John Ledingham for pointing out the way over the years.

GM:
I would like to thank my wife, Claire, for her support. I would also like to thank Professor Christopher Huang (CH) for teaching me physiology for many years and his immense dedication to the subject.

Contents

Foreword

The authors of this comprehensive physiology textbook have brought together their backgrounds in clinical practice and scientific research to produce a work in which the importance of an in-depth knowledge of physiology is translated into clinically relevant applications. The central relationship between the clinical practice of anaesthesia and the science of physiology is illustrated with precision throughout the volume, and the practical question and answer format provides a clear foundation for examination revision.

This book is an enjoyable and thought-provoking read, and brings together the crucial importance of understanding the principles of physiology which are as relevant to the practising clinician as they are to the scientist.

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Preface

An academically sound knowledge of both normal and abnormal physiology is essential for day-to-day anaesthetic practice, and consequently for postgraduate specialist examinations.

This project was initiated by one of us (DC) following his recent experience of the United Kingdom Fellowship of the Royal College of Anaesthetists examinations. He experienced difficulty locating textbooks that would build upon a basic undergraduate understanding of physiology. Many of the anaesthesia-related physiology books he encountered assumed too much prior knowledge and seemed unrelated to everyday anaesthetic practice.

He was joined by a Professor in Physiology (CH) and a Translational Medicine and Therapeutics Research Fellow (GM) at Cambridge University, both actively engaged in teaching undergraduate and postgraduate physiology, and in physiological research.

This book has been written primarily for anaesthetists in the early years of their training, and specifically for those facing postgraduate examinations. In addition, the account should provide a useful summary of physiology for critical care trainees, senior anaesthetists engaged in education and training, physician assistants in anaesthesia, operating department practitioners and anaesthetic nurses.

We believe the strength of this book lies in our mixed clinical and scientific backgrounds, through which we have produced a readable and up-to-date account of basic physiology, and provided links to anaesthetic and critical care practice. We hope to bridge the gap between the elementary physiology learnt at medical school and advanced anaesthesia-related texts. By presenting the material in a question and answer format, we aimed to emphasize strategic points, and give the reader a glimpse of how each topic might be assessed in an oral postgraduate examination. Our numerous illustrations seek to simplify and clearly demonstrate key points in a manner easy to replicate in an examination setting.

David Chambers
Christopher Huang
Gareth Matthews
Manchester and Cambridge.

Abbreviations

ACE	angiotensin-converting enzyme
ACh	acetylcholine
AChE	acetylcholinesterase
AChR	acetylcholine receptor
ADH	antidiuretic hormone
ADP	adenosine diphosphate
AF	atrial fibrillation
AGE	alveolar gas equation
ARDS	acute respiratory distress syndrome
ARP	absolute refractory period
ATP	adenosine triphosphate
AMP	adenosine monophosphate
ANS	autonomic nervous system
ANP	atrial natriuretic peptide
APTT	activated partial thromboplastin time
AV	atrioventricular
BBB	blood–brain barrier
BMR	basal metabolic rate
BNP	brain natriuretic peptide
BSA	body surface area
CA	carbonic anhydrase
C_aO_2	arterial oxygen content
CBF	cerebral blood flow
CC	closing capacity
CCK	cholecystokinin
CI	cardiac index
CMR	cerebral metabolic rate
CNS	central nervous system
CO	cardiac output
CoA	coenzyme A
COHb	carboxyhaemoglobin
COPD	chronic obstructive pulmonary disease
CPET	cardiopulmonary exercise test
CPP	cerebral perfusion pressure
CSF	cerebrospinal fluid
C_vO_2	venous oxygen content
CVP	central venous pressure
CVR	cerebral vascular resistance
DBP	diastolic blood pressure
DCT	distal convoluted tubule
DNA	deoxyribonucleic acid
ECF	extracellular fluid
ECG	electrocardiogram
EDV	end-diastolic volume
EEG	electroencephalogram
EF	ejection fraction
EPO	erythropoietin
ER	endoplasmic reticulum
ESV	end-systolic volume
ETT	endotracheal tube
FAD	flavin adenine dinucleotide
FEV_1	forced expiratory volume in 1 s
F_iO_2	fraction of inspired oxygen
FRC	functional residual capacity
FVC	forced vital capacity
GBS	Guillain–Barré syndrome
GFR	glomerular filtration rate
GI	gastrointestinal
Hb	haemoglobin
HbA	adult haemoglobin
HbF	fetal haemoglobin
HPV	hypoxic pulmonary vasoconstriction
HR	heart rate
ICF	intracellular fluid
ICP	intracranial pressure
IVC	inferior vena cava
LMA	laryngeal mask airway
LOH	loop of Henle
LOS	lower oesophageal sphincter
LV	left ventricle
LVEDP	left ventricular end-diastolic pressure
MAC	minimum alveolar concentration
MAO	monoamine oxidase
MAP	mean arterial pressure
MET	metabolic equivalent of a task
MetHb	methaemoglobin
MG	myasthenia gravis
MPAP	mean pulmonary artery pressure
MW	molecular weight
N_2O	nitrous oxide
NAD^+	nicotinamide adenine dinucleotide
NMJ	neuromuscular junction
OER	oxygen extraction ratio
PAC	pulmonary artery catheter
P_aO_2	arterial tension of oxygen
P_aCO_2	arterial tension of carbon dioxide
P_B	barometric pressure
PCT	proximal convoluted tubule
PCWP	pulmonary capillary wedge pressure
PE	pulmonary embolism
PEEP	positive end-expiratory pressure
$PEEP_e$	extrinsic PEEP
$PEEP_i$	intrinsic PEEP
PEFR	peak expiratory flow rate
PNS	peripheral nervous system
PPP	pentose phosphate pathway
PRV	polycythaemia rubra vera
PT	prothrombin time

PTH	parathyroid hormone
PVR	pulmonary vascular resistance
RAA	renal–angiotensin–aldosterone
RAP	right atrial pressure
RBC	red blood cell
RBF	renal blood flow
RMP	resting membrane potential
RNA	ribonucleic acid
RR	respiratory rate
RRP	relative refractory period
RSI	rapid sequence induction
RV	residual volume
RVEDV	right ventricular end-diastolic volume
RVF	right ventricular failure
SA	sinoatrial
S_aO_2	arterial haemoglobin oxygen saturation
SBP	systolic blood pressure
SR	sarcoplasmic reticulum
SV	stroke volume
SVC	superior vena cava
SVR	systemic vascular resistance
SVV	stroke volume variation
TF	tissue factor
TLC	total lung capacity
TOE	trans-oesophageal echocardiography
$\dot{V}/\dot{Q}$	ventilation–perfusion
$\dot{V}_A$	alveolar ventilation
VC	vital capacity
$\dot{V}_E$	minute ventilation
V_T	tidal volume
vWF	von Willebrand factor