ABC of Transfer and Retrieval Medicine

Edited by Adam Low and Jonathan Hulme

WILEY Blackwell

www.abcbookseries.com

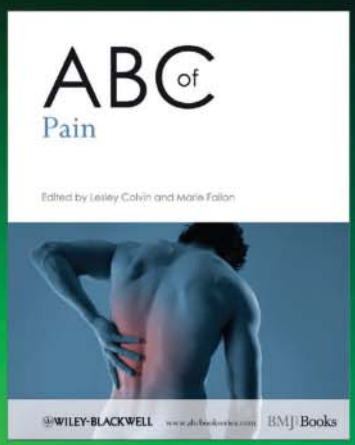
BMJ|Books

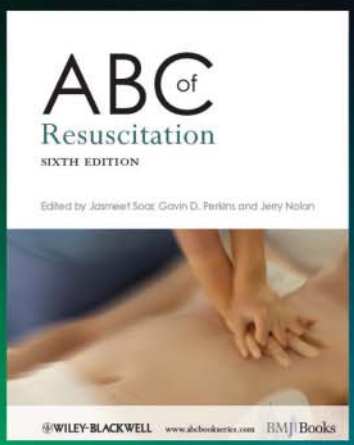
ABC of

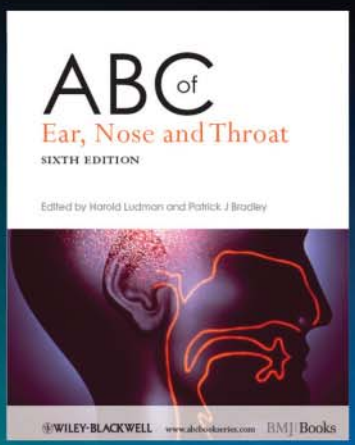
Transfer and Retrieval Medicine

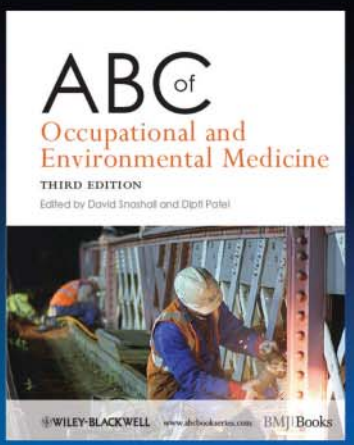
ABC series

An outstanding collection of resources for everyone in primary care









The *ABC* series contains a wealth of indispensable resources for GPs, GP registrars, junior doctors, doctors in training and all those in primary care

- **Highly illustrated, informative and a practical source of knowledge**
- **An easy-to-use resource, covering the symptoms, investigations, treatment and management of conditions presenting in day-to-day practice and patient support**
- **Full colour photographs and illustrations aid diagnosis and patient understanding of a condition**

For more information on all books in the *ABC* series, including links to further information, references and links to the latest official guidelines, please visit:

www.abcbookseries.com

WILEY Blackwell

BMJ | Books

ABC of

Transfer and Retrieval Medicine

EDITED BY

Adam Low

Specialist Registrar in Anaesthetics
West Midlands Deanery
West Midlands Central Accident Resuscitation & Emergency (CARE) Team
West Midlands Ambulance Service NHS Foundation Trust Medical Emergency Response Incident Team (MERIT), UK
AMREF Flying Doctors, Kenya

Jonathan Hulme

Consultant in Intensive Care Medicine and Anaesthesia, Sandwell and West Birmingham Hospitals NHS Trust
Honorary Senior Clinical Lecturer, University of Birmingham, Birmingham
West Midlands Ambulance Service NHS Foundation Trust Medical Emergency Response Incident Team (MERIT)
Medical Director, West Midlands Central Accident Resuscitation & Emergency (CARE) Team
Mercia Accident Rescue Service (MARS) BASICS, UK

WILEY Blackwell

BMJ Books

This edition first published 2015, © 2015 by John Wiley & Sons Ltd.

BMJ Books is an imprint of BMJ Publishing Group Limited, used under licence by John Wiley & Sons.

Registered office: John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial offices: 9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
111 River Street, Hoboken, NJ 07030-5774, USA

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com/wiley-blackwell

Library of Congress Cataloging-in-Publication Data

ABC of transfer and retrieval medicine / edited by Adam Low, Jonathan Hulme.
p. ; cm.
Includes bibliographical references and index.
ISBN 978-1-118-71975-6 (pbk.)
I. Low, Adam, 1982- editor. II. Hulme, Jonathan, 1974- editor.
[DNLM: 1. Critical Care – methods. 2. Transportation of Patients. 3. Monitoring, Physiologic. 4. Patient Care Team. 5. Patient Transfer. WX 218]
RT87.T72
616.02′8 – dc23

2014020562

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Cover image: 12-03-13 © Paolo Cipriani. Medical emergency team arrives at street accident. Stock Photo: 31074458

Set in 9.25/12 MinionPro by Laserwords Private Ltd, Chennai, India

1 2015

Contents

Contributors, ix

Preface, xiii

List of Abbreviations, xv

1 Introduction, 1
A. Low and J. Hulme

SECTION 1 PHYSIOLOGY OF TRANSFER MEDICINE, 3

2 Acceleration, Deceleration and Vibration, 5
M. Sheils and C. Hore

3 Environmental Exposure and Noise, 9
P. Paal and M. Helm

4 Altitude Physiology, 13
Y. Wimalasena and C. Duncan

SECTION 2 CLINICAL CONSIDERATIONS, 19

5 Resuscitation and Stabilisation, 21
C. Reid and K. Habig

6 Patient Packaging and Nursing Care, 28
C. Small and F. Clarke

7 Mode of Transport, 31
A. Cadamy and T. Martin

8 International Repatriations, 36
B. Vadera

9 Critical Incidents, 39
J.M. Droogh and J.G. Zijlstra

SECTION 3 TRANSFER EQUIPMENT, 43

10 Electrical Supply and Batteries, 45
G. Roberts and J. Hulme

11 Transport Ventilators and Medical Gas Supply, 47
J. Bingham

12 Monitoring, 51
A. Corfield and S. Hearns

13 Drug Delivery, 54
J. Cuell and M. McCabe

14 Near Patient Testing and Imaging, 58
A. Low and T. Harris

15 Haemorrhage Control and Splinting, 63
A. Hughes and A. Weaver

16 Stretchers, Incubators and Vacuum Mattresses, 70
H. Bawdon and M. Ward

17 Personal Protective Equipment, 73
C. Bosanko and S. Hepburn

18 Communication and Navigation, 77
I. Locke

SECTION 4 PHARMACOLOGY OF TRANSFER MEDICINE, 81

19 Routes of Administration, 83
T. Nutbeam and R. Fenwick

20 Pre-hospital Sedation and Analgesia, 88
J. Hulme

21 Sedation and Neuromuscular Blockers, 92
E. Joynes and B. Munford

22 Inotropes and Vasopressors, 96
A. Fergusson and R. Tipping

23 Specialist Pharmacology: Haemostatics and Uterotonics, 100
P. Morgan and D. Lockey

SECTION 5 THE TRANSFER TEAM, 105

24 Managing and Leading a Transfer, 107
D. Ellis and S. Mazur

25 Teamwork and Communication, 111
C. McQueen and K. Thies

26 Non-technical Skills and Sources of Error, 115
C. McQueen and M. Horton

27 Standard Operating Procedures, Checklists and Documentation, 119
S. Sollid and O. Uleberg

28 Audit, Medicolegal and Ethical Aspects of Transfer Medicine, 122
G. Evetts, S. Cox, and R. Tipping

29 Training for Transfers, 126
J. Warwick and D. Quayle

SECTION 6 NEONATAL AND PAEDIATRIC TRANSFERS, 131

30 Anatomical and Physiological Considerations, 133
S. Revana

31 Neonatal Medical Transfers, 137
Lesley Jackson

32 Paediatric Medical Retrievals, 142
S. Ray and E. Polke

33 Paediatric Trauma Retrievals, 146
Mary Montgomery

34 Additional Considerations, 152
H. McNeilly and J. Hegarty

SECTION 7 SPECIALIST TRANSFERS, 155

35 Head & Spinal Injuries, 157
R. Protheroe and F. Lecky

36 Burns, 160
T. Muehlberger, M. Büeschges, and C. Ottoman

37 Polytrauma and Military Retrievals, 164
D. Keene and O. Bartells

38 Obstetric Transfers, 169
H. Simpson

39 Cardiac Transfers, 174
C. Westrope and C. Harvey

40 Contagious Patients, 178
R. MacDonald

41 Bariatric Patients, 183
Z. Dempsey and M. Ross

42 Acute Behavioural Disturbances, 187
M. Le Cong

43 Considerations Regarding Organ Donation, 190
Anders Aneman and William O'Regan

Appendix 1 Framework for Radiology Interpretation, 193

Appendix 2 Framework for Interpretation of Arterial Blood Gases, 194

Appendix 3 Example of a Triage Sieve, 195

Appendix 4 Example of a Transfer Checklist, 196

Appendix 5 Example of Equipment Inventory, 197

Appendix 6 Summary of useful National Guidelines, 201

Index, 203

Contributors

Anders Aneman
Senior Staff Specialist, Intensive Care Unit, Liverpool Hospital, South Western Sydney Local Health District
Conjoint Associate Professor, University of New South Wales, NSW, Australia

Oliver Bartells
Lieutenant Colonel Royal Army Medical Corps, Consultant Anaesthetist, Ministry of Defence Hospital Unit Northallerton, UK

Hannah Bawdon
Anaesthetic registrar, West Midlands Deanery
West Midlands Central Accident Resuscitation & Emergency (CARE) Team
West Midlands Ambulance Service NHS Foundation Trust Medical Emergency Response Incident Team (MERIT), UK

Jon Bingham
Consultant in Trauma, Resuscitation and Anaesthesia, Department of Anaesthesia, University Hospital of North Staffordshire, Stoke-on-Trent
Midlands Air Ambulance, Cosford
West Midlands Ambulance Service Medical Emergency Response Incident Team (MERIT)
North Staffordshire BASICs
West Midlands Central Accident Resuscitation & Emergency (CARE) Team, UK

Clare Bosanko
Specialty Doctor, Emergency Medicine, University Hospital North Staffordshire, Stoke-On-Trent; West Midlands Ambulance Service NHS Foundation Trust Medical Emergency Response Incident Team (MERIT), UK

Michael Büeschges
Resident, Universitätsklinikum Schleswig Holstein Campus Lübeck, Abteilung für Plastische Chirurgie, Intensiveinheit für Schwerbrandverletzte, Lübeck, Germany

Andrew Cadamy
Consultant in Intensive Care Medicine and Anaesthetics, NHS Greater Glasgow and Clyde, Glasgow, UK

Felicity Clarke
Specialist Registrar Intensive Care & Anaesthetics, University Hospital of North Staffordshire, NHS Trust, Stoke on Trent
PHEM Doctor, West Midlands Ambulance Service NHS Foundation Trust Medical Emergency Response Incident Team (MERIT), UK

Alasdair Corfield
Consultant, Emergency Medicine & Emergency Medical Retrieval Service
Honorary Clinical Associate Professor, University of Glasgow, Glasgow, UK

Stuart J Cox,
Senior Nurse, Critical Care and Aeromedical Transfer CEGA Air Ambulance, Dorset
Senior Charge Nurse, General Intensive Care Unit, University Hospital Southampton NHS Foundation Trust, Southampton, UK

James Cuell
Anaesthetic Registrar, West Midlands Deanery, Birmingham School of Anaesthesia, Birmingham, UK

Zoey Dempsey
Consultant Anaesthetist, Department of Anaesthesia and Pain Medicine, Royal Infirmary of Edinburgh, UK

Joep M. Droogh
Consultant in Intensive Care Medicine
Medical Coordinator Mobile Intensive Care Unit, Department of Critical Care, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands

Catriona Duncan
Consultant in Anaesthesia, Timaru District Hospital, Timaru, New Zealand

Daniel Ellis
Director, MedSTAR Emergency Medical Retrieval Service, South Australian Ambulance Service, Australia
Deputy Director of Trauma and Senior Consultant in Emergency Medicine, Royal Adelaide Hospital, Australia
Associate Professor, School of Public Health and Tropical Medicine, James Cook University, Queensland, Australia

George Evetts
Specialist Registrar Intensive Care & Anaesthesia, Royal Air Force, Imperial College School of Anaesthesia, UK

Rob Fenwick
Charge Nurse, Emergency Department, Shrewsbury and Telford Hospitals NHS Trust, UK.

Anna Fergusson
Anaesthetic Registrar, Peninsula Deanery, South West School of Anaesthesia, Plymouth, UK

Karel Habig

Position
Greater Sydney Area Helicopter, Emergency Medical Service, Ambulance Service NSW Rescue, Helicopter Base, Bankstown Airport, NSW, Australia

Tim Harris

Professor Emergency Medicine, QMUL and Barts Health NHS Trust London, UK

Chris Harvey

Adult and Paediatric ECMO Consultant, ECMO Department, University Hospitals of Leicester, Leicester, UK

Stephen Hearns

Consultant in Emergency Medicine, Royal Alexandra Hospital, Paisley
Lead consultant Emergency Medical Retrieval Service, Scotland, UK

Jo Hegarty

Consultant Neonatologist, Newborn Services, National Women's Health, Auckland City Hospital, Auckland, New Zealand

Matthias Helm

Assistant Professor, Head Section Emergency Medicine, Department of Anaesthesiology and Intensive Care Medicine, Federal Armed Forces Medical Centre, Ulm, Germany

Scott Hepburn

Consultant in Emergency Medicine and EMRS
EMRS Lead for Risk Management, Department of Emergency Medicine, Western Infirmary, Glasgow, UK

Craig Hore

ICU Staff Specialist, Liverpool Hospital ICU/ Retrieval Staff Specialist, Ambulance Service of New South Wales, Sydney, Australia

Martin Horton

Immediate Care Practitioner-nurse, Royal Air Force Emergency and pre hospital specialist MERT practitioner, Emergency Department, Heartlands Hospital, Birmingham, UK

Amy Hughes

Clinical Academic Lecturer in Emergency Response, Humanitarian and Conflict Response Institute, University of Manchester
Emergency Medicine Registrar, Derriford Hospital
Honorary Physician in Pre Hospital Care, London's Air Ambulance, Barts and The Royal London NHS Trust, UK

Jonathan Hulme

Consultant in Intensive Care Medicine and Anaesthesia, Sandwell and West Birmingham Hospitals NHS Trust
Honorary Senior Clinical Lecturer, University of Birmingham, Birmingham
West Midlands Ambulance Service NHS Foundation Trust Medical Emergency Response Incident Team (MERIT), UK
Medical Director, West Midlands Central Accident Resuscitation & Emergency (CARE) Team, UK
Mercia Accident Rescue Service (MARS) BASICS, UK
Midlands Air Ambulance, UK

Lesley Jackson

Consultant Neonatal Medicine and Regional Director, West of Scotland Neonatal Transport Service, Yorkhill Hospital, Glasgow, UK

Emma L. Joynes

Retrieval registrar, Careflight Darwin, NT, Australia

Damian D. Keene

Major, Specialist trainee Anaesthesia and Pre-Hospital Emergency Medicine, Department of Military Anaesthesia and Critical Care

Minh Le Cong

Assistant Professor in Retrieval Medicine, Royal Flying Doctor Service Queensland Section, Australia

Fiona Lecky

Clinical Professor and Honorary Consultant in Emergency Medicine, University of Sheffield and Salford Royal NHS Foundation Trust, Greater Manchester, UK

Ian Locke

Critical Care Paramedic, West Midland Ambulance Service, NHS Trust, Midlands Air Ambulance, UK

David Lockey

Consultant, North Bristol NHS Trust, Bristol, & London's Air Ambulance, UK
Hon. Professor University of Bristol, Bristol, UK

Adam Low

Specialist Registrar in Anaesthetics, West Midlands Deanery
West Midlands Central Accident Resuscitation & Emergency (CARE) Team, UK
West Midlands Ambulance Service NHS Foundation Trust Medical Emergency Response Incident Team (MERIT), UK
AMREF Flying Doctors, Kenya

Stefan Mazur

Chief Medical Officer, South Australian Ambulance Service
Senior Consultant, PreHospital and Retrieval Medicine, MedSTAR Emergency Medical Retrieval Service
Senior Consultant in Emergency Medicine, Royal Adelaide Hospital
Associate Professor, School of Public Health and Tropical Medicine, James Cook University, Australia

Russell D. MacDonald

Attending Staff, Emergency Services, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada
Associate Professor and Co-Director, Emergency Medicine Fellowship Program, Department of Medicine, University of Toronto, Toronto, Ontario, Canada
Medical Director and Chair, Quality Care Committee, Ornge Transport Medicine, Mississauga, Ontario, Canada

Terry Martin

Consultant in Anaesthesia and Intensive Care Medicine, Royal Hampshire County Hospital, Winchester
Medical Director, Capital Air Ambulance, Exeter, UK, Director, CCAT Aeromedical Training, UK
Board Director, AMREF Flying Doctors, Nairobi, Kenya
Board Director, European Aeromedical Institute (EURAMI), Tuebingen, Germany

Heather Mcneilly

Paediatric Registrar, West Midlands Deanery, Birmingham, UK

Michael McCabe
Consultant in Anaesthesia, Anaesthetic Department, Worcester Royal Infirmary, Worcester, UK

Carl McQueen
PHEM Doctor, Midlands Air Ambulance; West Midlands Ambulance Service, Medical Emergency Response Incident Team (MERIT), UK &NIHR Doctoral Research Fellow, University of Warwick, UK

Mary Montgomery
Consultant, Kids Intensive Care & Decision Support, Birmingham Children's Hospital, West Midlands, Birmingham, UK

Patrick Morgan
Specialist Registrar, North Bristol NHS Trust, Bristol

Thomas Muehlberger
Associate Professor, Department of Plastic & Reconstructive Surgery, DRK-Kliniken, Berlin, Germany

Blair Munford
Senior Specialist Anaesthetist, Liverpool Hospital
Senior Retrieval Physician, CareFlight
Conjoint Lecturer in Anaesthetics, UNSW, and Senior Lecturer in Physiology, UWS Medical School
Sydney, Australia

Tim Nutbeam
Consultant in Emergency Medicine, Derriford Hospital, Plymouth Hospitals NHS Trust, Plymouth
West Midlands Ambulance Service NHS Foundation Trust Medical Emergency Response Incident Team (MERIT), UK

William O'Regan
Senior Staff Specialist, Intensive Care Unit, Liverpool Hospital, South Western Sydney Local Health District
Consultant for Careflight International Retrieval Service, Sydney, Australia

Christian Ottomann
Associate Professor, Universitätsklinikum Schleswig, Holstein Campus Lübeck, Sektion für Plastische Chirurgie und Handchirurgie, Intensiveinheit für, Schwerbrandverletzte, Lübeck, Germany

Peter Paal
Associate Professor, Department of Anaesthesiology and Critical Care Medicine, Medical University Innsbruck, Innsbruck, Austria
Helicopter Emergency Medical Service Christophorus 1, Innsbruck, Austria

Eithne Polke
Retrieval coordinator, Children's Acute Transport Service, Great Ormond Street Hospital for Children NHS Trust, London, UK

Richard Protheroe
Consultant in Critical Care Medicine and Neuro-Anaesthesia, Salford Royal NHS Foundation Trust, Salford, Greater Manchester, UK

David Quayle
Chief Flight Nurse, Air Medical Ltd, London Oxford Airport, UK

Samiran Ray
Consultant, Children's Acute Transport Service, Great Ormond Street Hospital for Children NHS Trust, London, UK

Cliff Reid
Senior Staff Specialist and Director of Training, Greater Sydney Area Helicopter Emergency Medical Service, NSW Ambulance, Australia
Clinical Associate Professor in Emergency Medicine, University of Sydney, Australia

Sanjay Revenna
Consultant, Kids Intensive Care & Decision Support, Birmingham Children's Hospital, West Midlands, Birmingham, UK

Gareth Roberts
Department of Anaesthesia, University Hospital of Wales, UK

Mark Ross
Specialist Trainee Registrar in Anaesthesia, Department of Anaesthesia and Pain Medicine, Royal Infirmary Edinburgh, UK

Mark Sheils
Flight Doctor, Careflight NT, Nightcliff, Darwin, Australia

Charlotte Small
Research Fellow, Anaesthesia and Critical Care, University Hospitals Birmingham NHS Foundation Trust (Queen Elizabeth Hospital) Birmingham, UK

Helen Simpson
Consultant Obstetrician, James Cook University Hospital, South Tees Foundation Trust, Middlesbrough, UK

Stephen J. M. Sollid
Dean, Norwegian Air Ambulance Academy, Norwegian Air Ambulance Foundation, Drøbak, Norway;
Consultant Anaesthetist, Air Ambulance Department, Oslo University Hospital, Oslo, Norway
Associate professor, University of Stavanger, Stavanger, Norway

Karl Thies
Consultant Anaesthetist Birmingham Children's Hospital, Birmingham
West Midlands Ambulance Service NHS Foundation Trust Medical Emergency Response Incident Team (MERIT)
Mercia Accident Rescue Service (MARS) BASICS, UK

Robert Tipping
Consultant Anaesthetist, Queen Elizabeth Hospital, Birmingham, UK,
West Midlands Ambulance Service NHS Foundation Trust Medical Emergency Response Incident Team (MERIT), UK
University Hospitals Birmingham NHS Foundation Trust (Queen Elizabeth Hospital), Birmingham, UK

Oddvar Uleberg
Consultant anaesthetist, Norwegian Air Ambulance Foundation, Drøbak, Norway
Department of aeromedical and clinical emergency services, St Olavs University Hospital, Trondheim, Norway

Bettina Vadera

Chief Executive and Medical Director of AMREF Flying Doctors, Kenya
Vice-President of EURAMI (European Aeromedical Institute)
Member of AMPA (Air Medical Physician Association), USA

Mathew Ward

Head of clinical practice, West Midlands Ambulance Service; Immediate Care Practitioner, West Midlands CARE Team, UK

Jon Warwick

Consultant Anaesthetist, Oxford University Hospitals NHS Trust, UK
Medical Director, Air Medical Ltd, London Oxford Airport, UK

Anne Weaver

Consultant in Emergency Medicine & Pre-Hospital Care, London's Air Ambulance, Royal London Hospital, UK

Claire Westrope

Consultant PICU/ECMO, University Hospital Leicester NHS Trust, Leicester, UK

Yashvi Wimalasena

Consultant in Emergency Medicine, Retrieval/HEMS Fellow, Greater Sydney Area HEMS, Ambulance Service of NSW Rescue Helicopter Base Bankstown, NSW, Australia

Jan G. Zijlstra

Professor in Intensive Care, Department of Critical Care, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands

Preface

The introduction of the Diploma in Transfer and Retrieval Medicine by the Royal College of Surgeons of Edinburgh in 2012 was the catalyst for ABC of Transfer and Retrieval Medicine. Reviewing the recommended reading for the Diploma, it was clear that there was no single revision guide to aid candidates' preparation; by using the Diploma curriculum as a framework, we could provide a useful addition to the highly acclaimed "ABC of…" series. Transfer Medicine is also a recognised component of anaesthetic training in the United Kingdom, with dedicated learning outcomes highlighted in the curriculum from the Royal College of Anaesthetists. On this background, we aim to provide a useful point of reference for all healthcare practitioners involved in the field of transfer and retrieval medicine.

We are indebted to all the individuals who have contributed their expertise to the book. As you will see, we have a distinctly multi-national contributor list from a range of healthcare backgrounds, with the specific aim of producing a text of relevance to all practitioners within the field, irrespective of country of practice. All the contributors have a wealth of experience and we are extremely grateful to them for sharing their expertise.

We would like to thank all the team at Wiley for their invaluable guidance, realistic timelines and patience with this project; our families for their unwavering support and tolerance, and our authors for agreeing to contribute to the book, adhering to timelines and stringent word counts!

Whilst on paper, the aim of "maintaining the same standard of care as the patient would receive in hospital throughout the course of the transfer" may sound straight forward, the reality is that it rarely is. This text is dedicated to all of you who move critically ill or injured patients to, or from, health care facilities at all hours of the day and night in often challenging circumstances.

Adam Low
Jonathan Hulme

List of Abbreviations

AAGBI	Association of Anaesthetists of Great Britain and Ireland
ACCM	American College of Critical Care Medicine
AC	Alternating current
ACT	Activated clotting time
ALS	Advanced life support
ANZCA	Australian & New Zealand College of Anaesthetists.
ATC	Acute trauma coagulopathy
ATLS	Advanced trauma life support
ARDS	Adult respiratory distress syndrome
BMI	Body mass index
BP	Blood pressure
CAA	Civil Aviation Authority
CAT	Combat application tourniquet
CCF	Congestive cardiac failure
CCNs	Critical care networks
CCP	Critical care paramedic
CBRN	Chemical, biological, radiological or nuclear
CAMTS	Commission on accreditation of medical transport systems
CCAST	Critical Care Air Support Team
CDR	Cognitive dispositions to respond
CDH	Congenital diaphragmatic hernia
CO	Cardiac output
CO (burns)	Carbon monoxide
CO_2	Carbon dioxide
COPD	Chronic obstructive pulmonary disease
CNS	Central nervous system
CPD	Continued professional development
CPR	Cardio-pulmonary resuscitation
CQC	Care Quality Commission
CSF	Cerebrospinal fluid
CVA	Cerebrovascular accident
CVC	Central venous catheter
CVP	Central venous pressure
CVS	Cardiovascular system
CXR	Chest X-ray
DBD	Donation after brain-stem death
DCD	Donation after circulatory death
DC	Direct current
DCR	Damage control resuscitation
ECG	Electrocardiogram
ECLA	Extracorporeal lung assist
ECLS	Extracorporeal life support
ECMO	Extracorporeal membrane oxygenation
ECT	Enhanced care teams
ED	Emergency Department
EMS	Emergency medical services
$ETCO_2$	End tidal carbon dioxide
ETT	Endotracheal tube
EURAMI	European Aero-Medical Institute
FAST	Focussed assessment with sonography in trauma
FFP	Fresh frozen plasma
FiO_2	Fractional inspired oxygen concentration
FRC	Functional residual capacity
FWAA	Fixed-wing air ambulance
GCS	Glasgow Coma Score
GMC	General Medical Council
GPS	Global positioning system
HAFOE	High air flow oxygen enrichment
HCPC	Health and Care Professionals Council
HDU	High dependency Unit
HEMS	Helicopter emergency medical system
HICAMS	Helicopter intensive care medical services
HIE	Hypoxic ischaemic encephalopathy
HIV	Human immunodeficiency virus
HLS	Helicopter landing site
HME filter	Heat moisture exchange filter
HR	Heart rate
HSE	Health and Safety Executive
IABP	Intra-aortic balloon pump
IBW	Ideal body weight
ICP	Intracranial pressure
ICU	Intensive Care Unit
ICS	Intensive Care Society
IFR	Instrumental flight rules
IM	Intramuscular
IN	Intranasal
iNO	Inhaled nitric oxide
IO	Intraosseus
ISS	Injury Severity Score
IUGR	Intra-uterine growth restriction
IUT	In utero transfer

IV	Intravenous
IVC	Inferior vena cava
IVH	Intra-ventricular haemorrhage
kPa	Kilopascals
km	Kilometres
LA	Left atrium
LCD	Liquid crystal display
LV	Left ventricle
MAD	Mucosal atomising device
MAP	Mean arterial pressure
MAS	Meconium aspiration syndrome
MCN	Managed clinical networks
MHRA	Medical and Healthcare Regulatory Agency
MRSA	Methicillin resistant staphylococcus aureus
MTC	Major trauma centre
MV	Minute volume
NACA	National Advisory Committee for Aeronautics
NAI	Non-accidental Injury
NEC	Necrotising enterocolitis
NIBP	Non-invasive blood pressure
NICE	National Institute for Health and Care Excellence
NICU	Neonatal intensive care unit
NiMH	Nickel metal hydride
NMBD	Neuromuscular blocking drugs
NMC	Nursing and Midwifery Council
NTS	Non-technical skills
NVG	Night vision goggles
O_2	Oxygen
O_3	Ozone
OR	Operating room
PACs	Picture Archiving & Communication system
PDA	Patent ductus arteriosus
PEEP	Positive end expiratory pressure
PHEM	Pre-hospital emergency medicine
PPHN	Persistent pulmonary hypertension of the newborn
POCT	Point of care testing
PPH	Post-partum haemorrhage
PRBC	Packed red blood cells
PRF	Patient record form
PTC	Patient transport compartment
PVR	Pulmonary vascular resistance
RDS	Respiratory distress syndrome
REBOA	Resuscitative endovascular balloon occlusion of the aorta.
RR	Respiratory rate
RS	Respiratory system
RTD	Regional trauma desk
RSI	Rapid sequence induction
SAR	Search and rescue
Sats	Saturations
SIRS	Systemic inflammatory response syndrome
SOPs	Standard operating procedures
SV	Stroke volume
SVC	Superior vena cava
SVR	Systemic vascular resistance
TB	Tuberculosis
TBSA	Total body surface area
TETRA	Terrestrial trunked radio
TPN	Total parenteral nutrition
TRM	Team resource management
TU	Trauma unit
TUC	Time of useful consciousness
TV	Tidal volume
UK	United Kingdom
UK-DMS	United Kingdom Defence Medical Services
UPS	Universal power supply
UV	Ultraviolet
V	Volts
VFR	Visual flight rules
VHF	Very high frequency
WHO	World Health Organization
°C	Degrees Celsius
<	Less than
>	Greater than

CHAPTER 1

Introduction

A. Low[1,2,3] *and J. Hulme*[1,2,4,5,6,7]

[1]West Midlands Central Accident Resuscitation & Emergency (CARE) Team, UK
[2]West Midlands Ambulance Service NHS Foundation Trust Medical Emergency Response Incident Team (MERIT), UK
[3]AMREF Flying Doctors, Kenya
[4]Intensive Care Medicine and Anaesthesia, Sandwell and West Birmingham Hospitals NHS Trust, UK
[5]University of Birmingham, UK
[6]Mercia Accident Rescue Service (MARS) BASICS, UK
[7] Midlands Air Ambulance, UK

Intensive care beds are a limited and often pressurised resource within any healthcare setting. As the complexity and breadth of surgical interventions increases, alongside longevity and associated co-morbidities, the requirement for critical care is expanding worldwide. In the developed world many healthcare systems are moving towards networked care: with tertiary centres for specialist care, meaning patients presenting to their local hospital may subsequently need to be transferred for definitive intervention (e.g. neuro/cardiothoracic/transplant surgery or an intervention such as hyperbaric oxygen therapy). Neonatal and paediatric intensive care facilities are becoming centralised, increasing the need for 'Retrieval Teams' who will travel to the patient, assist local health care professionals in resuscitation and stabilisation before transporting the patient back to base facility. The development of trauma networks may mean patients are transported longer distances from point of injury to Major Trauma Centres (MTCs), or stabilised at Trauma Units before onward transfer to a MTC for definitive multidisciplinary care. Regional Enhanced Care Teams (ECTs) are becoming increasingly common to assist in the primary management and transfer of these polytrauma patients. Figure 1.1 illustrates an example of a critically ill patient undergoing numerous transfers.

The increase in worldwide travel and business networks means people risk ill health while abroad. They may want or require repatriation for healthcare, family support or financial reasons. This request may be instigated by their medical insurance company, resulting in international transportation.

It is inevitable that critically ill patients will need to be moved at some point in their illness. This may be from point of injury or small healthcare facility to specialist care, or from one area of a healthcare facility to another. Pressures on critical care beds may necessitate movement of patients in order to manage local resources. In the UK, the NHS has created Critical Care Networks on a regional basis to facilitate this aspect of resource management. The principles and risks associated with moving any critically ill patient are discussed in depth in this book.

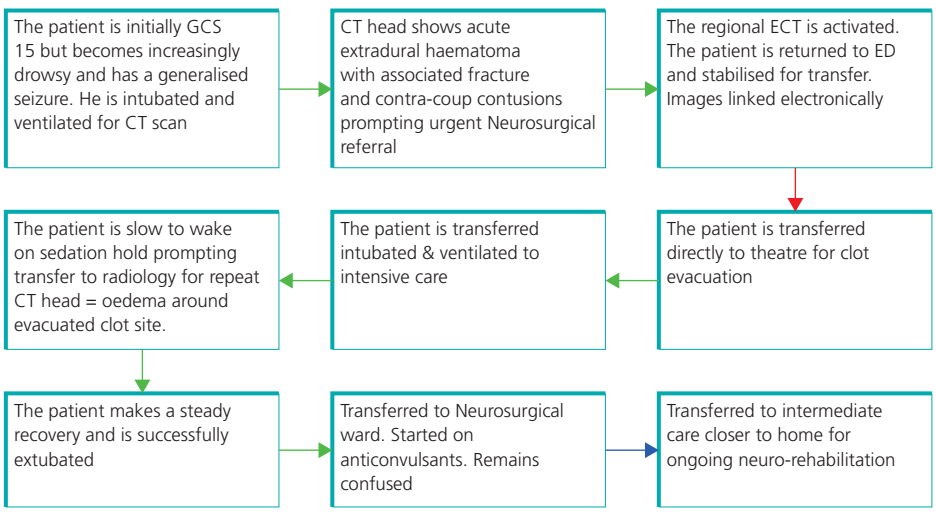


Figure 1.1 A 20-year-old male is assaulted and hits his head on the pavement with brief loss of consciousness. He is assessed on scene by paramedics who stabilise him and transfer him to the nearest Emergency Department. Green arrow, intra-hospital transfer; red arrow, secondary retrieval; blue arrow, repatriation.

ABC of Transfer and Retrieval Medicine, First Edition.
Edited by Adam Low and Jonathan Hulme.

The following definitions and concepts are important to understand:

- *Retrieval*: deployment of a specialist team of appropriately trained health care professionals to the patient's location to resuscitate and stabilise prior to transfer to definitive care.
- *Transfer*: the movement of a patient (not necessarily critically ill), from one location (or healthcare facility) to another.
- *Primary retrieval*: from a pre-hospital location to hospital.
- *Secondary retrieval*: movement from a healthcare facility with limited resources/expertise to a specialist care facility.
- *Tertiary retrieval*: movement from one specialist care facility to another, or for bed availability.
- *Repatriation*: retrieval from distant or international health care facility to patient's local hospital or specialist care unit.
- *Inter-hospital transfer*: movement of a patient from one hospital facility to another.
- *Intra-hospital transfer*: movement of a patient from one department to another within the same hospital buildings.

Movement of critically ill patients can be achieved via a variety of transport modalities, selection of which requires clinical, financial and logistical consideration.

The movement of critically ill patients is not without risks to patient and team (summarised in Box 1.1). Historical data have suggested that retrievals and transfers may be associated with increased mortality and length of hospital stay, with increased incidence of hypoxaemia and hypotension, persisting upon arrival at the receiving facility (see Further reading).

Box 1.1 **Potential risks encountered during patient transfers**

Environmental exposure
Road traffic collision
Equipment failure
Physiological instability
- hypoxaemia
- arrhythmias
- hypotension
- hypertension
- raised intracranial pressure
- death during transfer

Acknowledgement of these factors has resulted in the development of dedicated transfer and retrieval teams with associated clinical governance/training schemes, standardised equipment and standardised operating procedures to optimise patient safety (Box 1.2). All these factors will help to ensure 'the rule of RIGHT':

The RIGHT patient is taken at the RIGHT time, by the RIGHT people to the RIGHT place, using the RIGHT transport modality and receiving the RIGHT clinical care throughout.

Box 1.2 **Key components to being a part of an effective retrieval team**

Understanding of the physiological consequences of moving critically ill patients
Good clinical acumen and skill to assess and stabilise critically ill patients
Familiarity and understanding of equipment utilised
Familiarity and understanding of commonly used drugs
Good communication between the team, base hospital and receiving hospital
Good management and leadership skills
Appreciation of ethical and legal issues surrounding patient transfers and retrievals
Working within ones scope of practice and clinical governance scheme

This book aims to introduce the reader to all these different aspects of transfer and retrieval medicine. It is no substitute for hands-on clinical experience, but we hope it will provide a useful reference for any practitioner (paramedic, nurse or doctor) involved in the transfer and retrieval of critically ill patients.

Further reading

Flabouris A, Hart GK, George C. Outcomes of patients admitted to tertiary intensive care units after interhospital transfer: comparison with patients admitted from emergency departments. Crit Care Resusc 2008;10(2): 97–105.

Flabouris A, Hart GK, George C. Observational study of patients admitted to intensive care units in Australia and New Zealand after interhospital transfer. Crit Care Resusc 2008;10(2):90–6.

Section 1

Physiology of Transfer Medicine

CHAPTER 2

Acceleration, Deceleration and Vibration

M. Sheils[1] *and C. Hore*[2]

[1]Careflight NT, Australia
[2]Ambulance Service of New South Wales, Austalia

OVERVIEW

This chapter will enable the reader to:

- discuss gravity in relation to the flight environment
- list the origins of negative, positive, linear accelerations and radial accelerations
- understand the value of appropriate positioning and orientation of patients for transfers
- discuss the key fundamentals of crashworthiness in road and air modes of patient transport
- discuss the physics of vibration, harmonics and resonance and the physiological/physical consequences
- list the sources of mechanical vibration in road and air modes of patient transport.

Introduction

Any patient being moved will experience acceleration and vibration, irrespective of mode of transport. In the critically ill, these can have significant physiological impact that the transferring team must be aware of. This chapter will discuss the physics, sources and physiological consequences of acceleration and vibration. The importance of crashworthiness in reducing exposure to short-duration acceleration and protective strategies in limiting the effects of long-duration accelerations and vibration will also be considered.

Acceleration

Physics of acceleration

- *Speed*: The distance travelled in a given unit of time regardless of direction, usually measured as miles/kilometres per hour or metres per second. Air travel is measured as nautical miles per hour (knots).
- *Velocity*: Speed applied to a given direction, e.g. 300 knots West.
- *Force*: Newton's first law states that an object will remain at a constant velocity or state of rest unless a force is applied to it. Force therefore causes acceleration. The standard international (SI) unit for force is a newton (N): a force that will accelerate a mass of 1 kg × 1 m/s^2. The gravitational pull of the earth exerts 9.81 N on any mass. That is, if an object with a mass of 1 kg is dropped from a height, gravity would cause it to accelerate at 9.81 m/s^2 until terminal velocity is reached. The 9.81 N force of gravity is better known as 1 G. Inhabitants of this planet have evolved so that our physiological performance is optimised under the gravitational force of 1 G.
- *Weight*: When the force of gravity is applied to a mass it gives rise to the force we sense as weight. If an 80-kg patient is subjected to an accelerative force of 2 G they would weigh 160 kg.
- *Acceleration*: A rate of change of velocity measured in metres per second squared. Acceleration can be a positive number or a negative number (deceleration). Newton's second law states that acceleration is directly related to the force applied to it and inversely proportional to the mass of the object.

Newton's third law states that for every action or force, there is an equal and opposite reaction. Therefore when we are accelerated by one force in one direction, we will be exposed to a force in the opposite direction, known as the reactive or inertial force. The reactive force felt during acceleration is known as G force and is labelled according to the magnitude (in multiples of Gs) and the direction it is applied in relation to the body (Figure 2.1).

G force along the vertical axis of the body is labelled Gz, with a positive vertical G force (+Gz) when the body is accelerated upwards and the reactive force pushes down. This is felt as an increased weight. A negative vertical G force (–Gz) occurs when the body is accelerated downwards with the reactive force pushing upwards. G force along the anteroposterior axis is labelled Gx. Positive anteroposterior G force (+Gx) occurs when the body is accelerated forward and the reactive force pushes the body backwards. Negative anteroposterior G force (–Gx) occurs as the body decelerates or accelerates in a backwards direction with the reactive force pushing the body forward. G force applied laterally is labelled Gy. Positive lateral G force (+Gy) occurs when the body is accelerated to the right and negative lateral G force (–Gy) when the body is accelerated to the left.

Sources of acceleration

Broadly speaking acceleration can be defined as long-duration accelerations, lasting greater than 2 seconds in excess of 1 G, or short

ABC of Transfer and Retrieval Medicine, First Edition.
Edited by Adam Low and Jonathan Hulme.