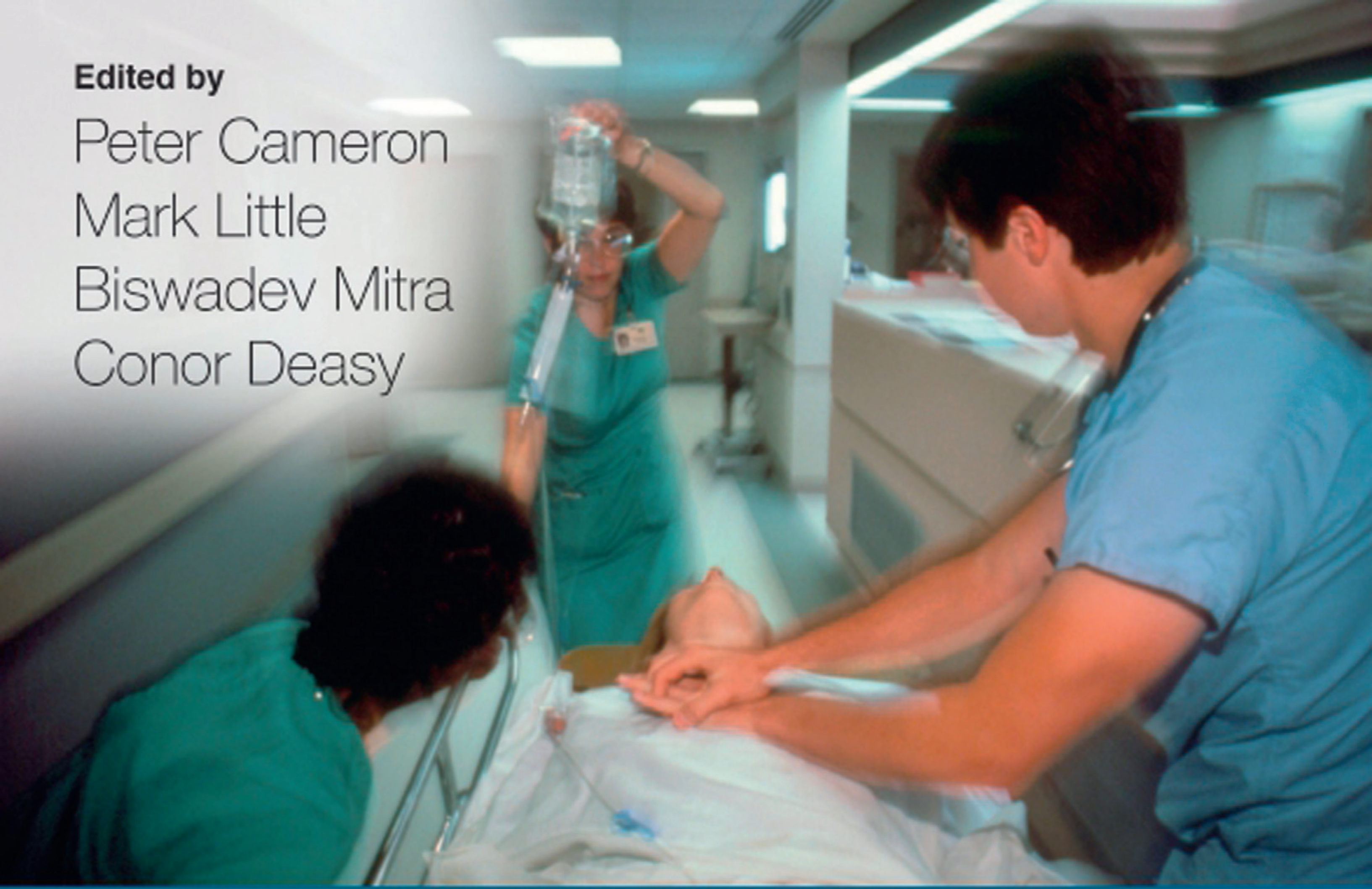

Edited by
Peter Cameron
Mark Little
Biswadev Mitra
Conor Deasy

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Fifth Edition

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ADULT EMERGENCY MEDICINE

Fifth Edition

EDITED BY

Peter Cameron MBBS MD FACEM
Professor of Emergency Medicine, Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Victoria, Australia; Emergency Physician, Emergency and Trauma Centre, The Alfred Hospital, Melbourne, Victoria, Australia

Mark Little MBBS FACEM MPH&TM DTM&H IDHA
Emergency Physician and Clinical Toxicologist, Department of Emergency Medicine, Cairns Hospital, Cairns, Queensland, Australia; Clinical Toxicologist, New South Wales Poisons Information Service, New South Wales, Australia

Biswadev Mitra MBBS MHSM PhD FACEM
Emergency Physician, Alfred Hospital Emergency and Trauma Centre; Professor, Critical Care Research, Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Victoria, Australia

Conor Deasy MB DCH Dip IMC Dip Tox FRCEM PhD
Clinical Lead and Consultant in Emergency Medicine, Cork University Hospital, Cork, Ireland; Senior Lecturer, Emergency Medicine, University College Cork, Cork, Ireland; Deputy Medical Director, National Ambulance Service, Dublin, Ireland; Associate Adjunct Professor, School of Primary Care, Monash University, Melbourne, Victoria, Australia

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Content Development Specialist: Fiona Conn
Senior Project Manager: Karthikeyan Murthy
Designer: Amy Buxton
Illustration Manager: Narayanan Ramakrishnan
Marketing Manager: Deborah Watkins

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Preface

The discipline of emergency medicine continues to grow, and the subspecialties continue to expand in breadth and number. Since the first edition of this book 20 years ago, there has been enormous change in the way emergency care is delivered. This has occurred both in countries where emergency medicine originally developed and in those where it was originally felt that it might not have a role because it was a 'first-world' specialty, limited in application because of cost. The World Health Organization is now completely changing this view and regards emergency medicine as the cornerstone of response to acute illness, even in countries with very limited resources.

An emergency medicine program provides essential structure to develop a response to disasters, epidemics and humanitarian crises. The importance of emergency medicine in ensuring an appropriate response to all acute medical problems is also becoming more obvious. This edition covers not only specific medical emergencies such as cardiac, neurological and respiratory emergencies, it also covers the complex organizational issues for disaster planning and response, humanitarian emergencies and refugee medicine.

A further feature of this book is that governance, training, research and organizational subjects are covered, to give the reader some frameworks to understand the complexity of managing major emergency systems of care.

The clinical subjects in this edition have all been extensively reviewed and updates provided. There have been major updates in some of the clinical chapters, such as airway, shock and sepsis, because guidelines have changed rapidly. The imaging chapters have also evolved with changing practice, improved technology and evidence for inclusion of emergency physician interpretation of imaging becomes more robust.

Despite the rapid escalation of topics and depth of potential content, we have tried to keep the book to a manageable length, to ensure accessibility for readers. As part of this process, we have moved many of the references online, so that readers who are interested can still access more detailed information. We have also moved many images and photos online to reduce printed matter. The additional material can be found in the free e-book that comes with the printed version—see inside front cover.

In a book of this size and complexity, there are many people to thank—more than 200 contributing authors from around the world, and their family and friends who were deprived of their company whilst writing the chapters! The production staff from Elsevier was extremely helpful, especially Fiona Conn for overall coordination. A special thanks to Angela Hodges, for assisting the editors and authors to complete the book in a reasonable timeframe.

Peter Cameron
Mark Little
Biswadev Mitra
Conor Deasy

Contributors

Jonathan Abrahams, MPH BSc Grad Dip (Population Health) Cert. (Emergency Management)
Country Health Emergency Preparedness and International Health Regulations, World Health Organization, Geneva, Switzerland

Nicholas Adams, MBBS
Emergency Physician, Alfred Health, Melbourne, Victoria, Australia

Peter Aitken, MBBS FACEM EMDM MClinEd DrPH
Senior Director, Health Disaster Management Unit, Queensland Health, Brisbane, Queensland, Australia

Sam Alfred, MBBS FACEM Dip Tox
Emergency Physician and Clinical Toxicologist, Royal Adelaide Hospital, Adelaide, South Australia, Australia

Philip Aplin, MBBS FACEM
Emergency Physician, Emergency Department, Flinders Medical Centre, Adelaide, South Australia, Australia

Michael W. Ardagh, ONZM PhD MBChB DCH FACEM
Professor of Emergency Medicine, University of Otago, Christchurch, New Zealand

Sean Arendse, BSc MBBS FACEM PG Dip (Clin Derm) AKC
Senior Emergency Physician, The Alfred Hospital, Melbourne, Victoria, Australia

Jason Armstrong, MBChB FACEM
Emergency Physician and Clinical Toxicologist, Sir Charles Gairdner Hospital, Perth; Medical Director, WA Poisons Information Centre, Perth, Western Australia, Australia

Michael R. Augello, MBBS FACEM
Emergency Physician, Emergency Department, St Vincent's Hospital, Melbourne; Honorary Fellow, Department of Medicine, The University of Melbourne, Melbourne, Victoria, Australia

Michael Baker, MBBS (Hons) FACEM (PEM) DipCH
Emergency Physician, Sir Charles Gairdner Hospital and Princess Margaret Hospital for Children, Perth, Western Australia, Australia

Ashis Banerjee, MBBS MRCS LRCP MS FRCS (Eng) FRCS (Edin) FCEM DTM&H (Lond)
Consultant/Royal Free London NHS Foundation Trust, London; Honorary Senior lecturer in Emergency Medicine, University of Hertfordshire, Hatfield, United Kingdom

Therese Becker, BSc MBBS FACEM
Emergency Physician and Clinical Toxicologist, Prince of Wales Hospital, Sydney, New South Wales, Australia

Anthony J. Bell, MBBS FACEM MBA MPH FRACMA
Director of Medical Services, The Wesley Hospital, Brisbane, Queensland, Australia

Stephen A. Bernard, MD
Senior Staff Specialist, The Alfred Hospital, Melbourne; Medical Director, Ambulance Victoria, Melbourne, Victoria, Australia

Shom Bhattacharjee, MBBS FRACP
Consultant Rheumatologist, The Alfred Hospital, Melbourne, Victoria, Australia

Matthew Bode, MBChB FACEM
Emergency Physician, St Vincent's Hospital and Sutherland Hospital, Sydney, New South Wales, Australia

Peter Bosanac, MBBS MMed (Psychiatry) MD FRANZCP Grad Dip MH Science (Clinical Hypnosis)
Director Clinical Services, Mental Health, St Vincent's Hospital, Melbourne, Victoria, Australia

Bethany Boulton, BPharm Grad Cert Int Health MBBS (Hons) FACEM
Senior Staff Specialist, Department of Emergency Medicine, Sunshine Coast Hospital and Health Service, Queensland; Senior Lecturer, Coast Clinical Unit, University of Queensland, Brisbane, Queensland, Australia

David A. Bradt, MD MPH FACEM FAFPHM FACEP DTM&H
Johns Hopkins University, Baltimore, Maryland, United States

George Braitberg, AM MBBS FACEM FACMT FRACMA MBioethics MHlthServMt Dip Epi Biostats
Executive Director of Strategy, Quality and Improvement, Melbourne Health; Professor of Emergency Medicine, Head Emergency Stream, Centre for Critical Care Medicine, The University of Melbourne, Melbourne, Adjunct Professor Health Sciences Unit, Monash University, Melbourne, Victoria, Australia

Crispijn van den Brand, MD
Emergency Physician, Emergency Medicine, Haaglanden Medisch Centrum, The Hague, Netherlands

Victoria Brazil, MBBS FACEM MBA
Professor of Emergency Medicine, Faculty of Health Sciences and Medicine, Bond University, Gold Coast Health, Gold Coast, Queensland, Australia

Richard J. Brennan, MBBS MPH FACEM FIFEM
Director, Department of Emergency Management Operations, World Health Organization, Geneva, Switzerland

Anthony F.T. Brown, AM, FRCP FRCSEd FRCEM FACEM
Senior Staff Specialist, Emergency and Trauma Centre, Royal Brisbane and Women's Hospital, Brisbane; Professor of Emergency Medicine, Discipline of Anaesthesiology and Critical Care, Faculty of Medicine, University of Queensland, Queensland, Brisbane; Peer Support Examiner, Senior Court of Examiners, Australasian College for Emergency Medicine, Australia

Nicholas Buckley, MD FRACP
Professor of Clinical Pharmacology, University of Sydney, Sydney; VMO clinical toxicologist, The Children's Hospital at Westmead, Sydney, New South Wales, Australia

Peter Cameron, MBBS MD FACEM
Professor of Emergency Medicine, Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Victoria, Australia; Emergency Physician, Emergency and Trauma Centre, The Alfred Hospital, Melbourne, Victoria, Australia

Christopher Carman, MBBS PGDipSurgAnat
Emergency Registrar, The Alfred Emergency and Trauma Centre, Melbourne, Victoria, Australia

Kirsten Cassidy, MBChB DRCOG MRCGP FACEM
Emergency Physician, Emergency Department, St Vincent's Hospital, Fitzroy, Victoria, Australia

Betty S.H. Chan, MBBS FACEM PhD
Head of Clinical Toxicology Unit & Emergency Physician, Prince of Wales Hospital, Sydney; Clinical Toxicologist, New South Wales Poisons Information Centre, The Children's Hospital at Westmead, Sydney, New South Wales, Australia

Gar Ming Chan, MD FACEM
Staff Specialist in Emergency Medicine, Calvary Hospital, Lenah Valley, Tasmania, Australia

Raymond Chi Hung Cheng, MBChB MRCSEd FHKCEM FHKAM (Emergency Medicine)
Consultant, Accident and Emergency Department, Prince of Wales Hospital, Shatin, Hong Kong

Angela L. Chiew, BSci (Med) MBBS FACEM
Emergency Physician and Clinical Toxicologist, Prince of Wales Hospital, Randwick, Sydney, NSW, Australia; Clinical Toxicologist, NSW Poisons Information Centre, The Children's Hospital Westmead, New South Wales, Australia

Matthew W.G. Chu, MBBS (Hons) FACEM
Senior Specialist, Emergency Department Director, Medical Assessment Unit Director, Prevocational Education and Training Canterbury Hospital, Sydney, New South Wales, Australia

Flavia M. Cicuttini, MBBS (Hons) PhD DLSHTM FRACP FAFPHM
Head, Rheumatology Unit, The Alfred Hospital, Melbourne; Professor and head of Musculoskeletal Unit, School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia

James Collier, MBBS FACEM
Co-Director, Department of Emergency Medicine, Princess Alexandra Hospital, Brisbane, Queensland, Australia

Julie Considine, RN RM BN PhD
Professor of Nursing, Deakin University School of Nursing and Midwifery and Centre for Quality and Patient Safety Research – Eastern Health Partnership, Melbourne, Victoria, Australia

Geoffrey A. Couser, MBBS FACEM MEd
Senior Staff Specialist, Emergency Department Royal Hobart Hospital, Hobart; Clinical Associate Professor, School of Medicine, University of Tasmania, Hobart, Tasmania, Australia

Carmel Crock, MBBS FACEM BLitt
Director, Emergency Department, Royal Victorian Eye and Ear Hospital, Melbourne, Australia; Senior Lecturer, University of Melbourne, Victoria, Australia

John J. Cronin, MB, BCh, BAO, FRCEM, AFRCSI, FFSEM, DCH
Consultant in Emergency Medicine, St Vincent's University Hospital, Dublin, Ireland

Stephen Cusack, MB BSc FRCSI FRCEM
Professor of Emergency Medicine, University College Cork, Cork; Consultant in Emergency Medicine, Cork University Hospital, Cork, Ireland

Andrew H. Dawson, MBBS FRACP FRCP FCCP
Professor of Clinical Toxicology, Royal Prince Alfred Hospital, Sydney, New South Wales, Australia

Rebecca Day, MBBS MRCS FACEM
Co-Director of Emergency Medicine, Royal Darwin Hospital, Darwin, Northern Territory, Australia

Nadine de Alwis, MBBS BSci Dip Anat
ENT Surgeon, Royal Victorian Eye and Ear Hospital, Melbourne; Consultant ENT Surgeon, Cairns Hospital, Cairns, Queensland, Australia

Ryan De Cruz, MBBS (Hons) BMedSci FACD
Specialist Dermatologist, The Royal Melbourne Hospital, Melbourne, Victoria, Australia

Carol Douglas, MBChB FRACGP FAChPM
Director Palliative and Supportive Care Service, Royal Brisbane and Women's Hospital, Brisbane, Queensland, Australia

Michael A. Downes, MBChB FACEM
Emergency Physician and Clinical Toxicologist, Calvary Mater Newcastle Hospital, Waratah, New South Wales, Australia

Robert Dowsett, BMBS GDipClinEd FACEM
Visiting Medical Officer, Emergency Medicine, Calvary Hospital, Bruce, Canberra; Visiting Medical Officer, New South Wales Poisons Information Centre, The Childrens Hospital at Westmead, Sydney, New South Wales, Australia

Pieter van Driel, MD DEMT FNVSHA
Emergency Physician, Elisabeth-TweeSteden ziekenhuis (ETZ) Tilburg, Netherlands

Michelle van den Driesen, MBBS FACEM DTMH MPH MHML
Emergency Physician, Royal Melbourne Hospital, Melbourne, Victoria, Australia

Dino Druda, BMedSi (Hons) MBBS FACEM FRCP (Edin)
Emergency Physician and Clinical Toxicologist, Monash Health, Melbourne, Victoria, Australia

Stephen J. Dunjey, MBBS FACEM DDU
Consultant in Emergency Medicine, Royal Perth Hospital, Perth; Professor of Emergency Medicine, St John of God Hospital, Murdoch, Western Australia, Australia

Martin J. Dutch, BMedSci (Hons) MBBS (Hons) MPH&TM FACEM O.StJ.
Emergency Physician, Royal Melbourne Hospital, Melbourne; Medical Donation Specialist, DonateLife, Melbourne, Victoria, Australia

Diana Egerton-Warburton, MBBS FACEM MClinEpi MPH CCPU
Director of Emergency Medicine Research, Monash Medical Centre, Monash Health, Melbourne; Professor, School of Clinical Sciences at Monash Health, Monash University, Melbourne, Victoria, Australia

Daniel M. Fatovich, MBBS FACEM PhD
Professor of Emergency Medicine, Royal Perth Hospital, University of Western Australia, Perth; Head, Centre for Clinical Research in Emergency Medicine, Harry Perkins Institute of Medical Research, Perth; Director of Research, Royal Perth Hospital, Perth, Western Australia, Australia

Louise Finnel, MBChB FACEM PGDipClinEd GDipBHL
Emergency Medicine Specialist, Middlemore Emergency Department, Counties Manukau District Health Board, Auckland, New Zealand

Mark Fitzgerald, MBBS MD
Director, Trauma Service, The Alfred Hospital, Melbourne; Director, National Trauma Research Institute, Melbourne; Professor, Department of Surgery, Central Clinical School, Monash University, Melbourne; Medical Adviser, Ambulance Victoria, Melbourne, Victoria, Australia

Eoin Fogarty, FRCEM FACEM
Emergency Physician, Cork University Hospital, Cork, Ireland

James Fordyce, MBBS MPH FACEM GradCertSpMed
Emergency Physician, Monash Health, Melbourne, Victoria, Australia

Peter Fritz, MBBS (Hons) FACEM GCHPE
Emergency Physician, The Alfred Hospital, Melbourne; Adjunct Lecturer, Monash University, Melbourne, Victoria, Australia

Dean Fulford, MBChB BSc (Hons) MRCS (Eng) PgCert (Med Ed)
Emergency Medicine Registrar, Sir Charles Gairdner Hospital, Perth, Western Australia, Australia

James K. Galbraith, MBBS FRANZCO FRACS
Ophthalmic Surgeon, Royal Melbourne Hospital, Melbourne, Victoria, Australia

Alan Gault DipClinTox, FACEM MBChB BAO BA (HSc)
Emergency Medicine Staff Specialist and Clinical Toxicologist, Western Australia Poison Information Centre, Sir Charles Gairdner Hospital, Perth; New South Wales Poisons Information Centre, The Children's Hospital at Westmead, Sydney, New South Wales, Australia

Michael J. Gingold, BMedSc (Hons) MBBS (Hons) FRACP
Consultant Rheumatologist, Monash Health, Melbourne, Victoria, Australia

Robert Gocentas, MBBS DipClinEpi FACEM
Emergency Physician, Emergency & Trauma Centre, Alfred Health, Melbourne, Victoria, Australia

Neil A. Goldie, MBBS FACEM
Service Director – Emergency Medicine, Monash Health, Melbourne, Victoria, Australia

Adrian Goudie, BMedSci (Hons) MBBS FACEM DDU
Emergency Physician, Fiona Stanley Hospital, Perth, Western Australia, Australia

Colin A. Graham, MBChB MPH MD FRCP FRCS FIMCRCSEd FCCP FRCEM FHKCEM FHKAM (Emergency Medicine)
Professor of Emergency Medicine, Chinese University of Hong Kong; Honorary Consultant in Emergency Medicine, Prince of Wales Hospital, Shatin, Hong Kong; Editor-in-Chief, European Journal of Emergency Medicine, London, United Kingdom

Andis Graudins, MBBS (Hons) PhD FACEM FACMT
Professor of Emergency Medicine and Clinical Toxicology Research, Monash University, Melbourne; Consultant Emergency Physician and Clinical Toxicologist, Monash Dandenong, Melbourne; Visiting Consultant Clinical Toxicologist, New South Wales Poisons Information Centre, The Children's Hospital at The Children's Hospital at Westmead, Sydney; Visiting Consultant Clinical Toxicologist, Victorian Poisons Information Centre, Austin Hospital, Heidelberg, Victoria, Australia

Digby Green, BSc MBChB FACEM
Emergency Physician, Cairns Hospital, Queensland, Australia

Tim Green, MBBS FACEM
Senior Staff Specialist, Royal Prince Alfred Hospital, Sydney; Clinical Senior Lecturer, Sydney; Medical School, University of Sydney, Sydney, New South Wales, Australia

Shaun Greene, MBChB MSc FACEM FACMT
Emergency Physician, Austin Health, Melbourne; Clinical Toxicologist, Victorian Poisons Information Service, Melbourne, Victoria, Australia

Christopher Groombridge, MBBS MA (Cantab) MSc DOHNS (RCSEng) DRTM (RCSEd) DIMC (RCSEd) MRCS FACEM
Emergency Physician, The Alfred Hospital, Melbourne; Adjunct Lecturer, Monash University, Melbourne, Victoria, Australia

Naren Gunja, MBBS MSc (ForTox) FACEM FACMT
Clinical & Forensic Toxicologist, Western Sydney Health, NSW; Clinical Toxicologist, NSW Poisons Information Centre, Sydney, NSW; Clinical Associate Professor, Sydney Medical School, New South Wales, Australia

Barry Gunn, MBBS FACEM
Emergency Physician, Western Health, Melbourne, Victoria, Australia

Kim Hansen, MBBS (Hons) MBA FACEM
Director of Emergency Services, St Andrew's War Memorial Hospital, Brisbane; Senior Staff Specialist, Emergency Department, The Prince Charles Hospital, Brisbane; Senior Lecturer, Faculty of Medicine, University of Queensland, Brisbane, Queensland, Australia

Kenneth Heng, MBBS FRCS (A&E) Edin FAMS MPHEd
Senior consultant Tan Tock Seng Hospital Singapore, Adj Assoc Professor LKC School of Medicine, Singapore

Arthur Hennessy, MB BCh BAO Dip Med Tox MRCSI FRCEM
Consultant in Emergency Medicine, St. James's Hospital, Dublin, Ireland

Ruth Hew, MBBS BA MSc (ClinEpi) FACEM
Emergency Physician, Sunshine Hospital, Melbourne, Victoria, Australia

Ian Hewson, BDSc FRACDS MRACDS
Director of Dental Services, The Alfred Hospital, Melbourne, Victoria, Australia

Rosslyn Hing, BSc (Med) MBBS FACEM
Emergency Physician, Staff Specialist, Royal Prince Alfred Hospital, Sydney, New South Wales, Australia

Blair Hobbs, B.Sc.P.N, PostGradDip ACN, MANP (NP), MACMHN
Team Leader/Nurse Practitioner, Consultation Liaison and Emergency Psychiatry Service, Alfred Mental and Addiction Health, The Alfred Hospital, Melbourne, Victoria, Australia

Kerry A. Hoggett, MBBS GCertClinTox FACEM
Emergency Physician and Clinical Toxicologist, Royal Perth Hospital, Perth; Clinical Toxicologist, New South Wales Poisons Information Centre, The Children's Hospital at Westmead, Sydney, New South Wales, Australia

Anthony D. Holley, BSc MBBCh DipPaeds DipDHM FACEM FCICM
Senior Staff Specialist, Royal Brisbane and Women's Hospital, Brisbane; Senior Lecturer, School of Medicine, University of Queensland, Brisbane, Queensland, Australia

Craig Hore, MBBS FACEM FCICM MHPol
Clinical Director of Intensive Care, Port Macquarie Base Hospital, Port Macquarie; Conjoint Senior Lecturer, Faculty of Medicine, Rural Clinical School, University of New South Wales, Port Macquarie, New South Wales, Australia

Kevin K.C. Hung, MBChB MPH EMDM MRCSEd FRCEM FHKCEM FHKAM (Emergency Medicine)
Assistant Professor in Emergency Medicine, Chinese University of Hong Kong; Honorary Specialist in Emergency Medicine, Prince of Wales Hospital, Shatin, Hong Kong

Jennie Hutton, MBChB MPH FACEM
Emergency Physician, St Vincent's Hospital, Melbourne, Victoria, Australia

Sue Ieraci, MBBS FACEM

Arun Ilancheran, MBBS (Hons) FACEM
Emergency Physician, The Alfred Emergency and Trauma Centre, Melbourne, Victoria, Australia

Geoffrey Isbister, BSc MBBS FACEM MD
Senior Staff Specialist, Department of Clinical Toxicology and Pharmacology, Calvary Mater Newcastle Hospital, Newcastle; Professor, School of Medicine and Public Health, University of Newcastle, Newcastle; Consultant, New South Wales Poisons Information Centre, The Children's Hospital at Westmead, Sydney, New South Wales, Australia

Katherine Isoardi, BMed FACEM GradDip ClinTox
Emergency Physician and Clinical Toxicologist, Princess Alexandra Hospital, Brisbane; Clinical Toxicologist, Queensland Poisons Information Centre, Lady Cilento Children's Hospital, Brisbane, Queensland, Australia

Christine Jackman, MBBS FACEM MPHE
Senior Emergency Physician, Cabrini Hospital, Cabrini Health, Victoria; Senior Lecturer Monash University, Eastern Health Clinical School, Box Hill, Victoria, Australia

Angela Jackson, RN RM NP. B Nurs, Dip Nurs, Crit Care Cert, MPH&TM LLB Dip Law, M Nursing (NP), IDHA
Emergency Nurse Practitioner, Department of Emergency Medicine, Cairns Hospital, Cairns, Queensland, Australia

Nazila Jamshidi, BPharm (Hons) PhD MBBS
Clinical pharmacology/Addiction and General Medicine Advanced Trainee, Drug Health Services, Royal Prince Alfred Hospital, Sydney, New South Wales, Australia

Dushan Jayaweera, MBBS (Hons) FACEM DipTox
Emergency Physician and Clinical Toxicologist, Conjoint Senior Lecturer, Western Sydney Health, New South Wales Poisons Information Centre, The Children's Hospital at Westmead, School of Medicine, Western Sydney University, Sydney, New South Wales, Australia

Paul A. Jennings, BN GradCertAdvNsg MClinEpi PhD
Clinical Manager, Ambulance Victoria, Melbourne, Australia; Adjunct Associate Professor, Community Emergency Health and Paramedic Practice, Monash University, Melbourne, Victoria, Australia

Cecil S. Johnny, MBBS MS (Gen Surg) FACEM
Consultant, The Alfred Emergency and Trauma Centre, Melbourne, Victoria, Australia

Daryl A. Jones, BSc (Hons) MBBS FRACP FCICM MD PhD
Consultant Intensive Care Specialist, Austin Health, Melbourne; Associate Professor SPHPM Monash University, Melbourne; Adjunct Associate Professor, The University of Melbourne, Melbourne; Medical Director Critical Care, Outreach Austin Hospital, Melbourne, Victoria, Australia

Anthony P. Joseph, MBBS FACEM
Senior Staff Specialist and Director of Trauma, Royal North Shore Hospital, Sydney; Associate Professor, Sydney Medical School, University of Sydney, Sydney, New South Wales, Australia

David V. Kaufman, MBBS FRANZCO FRACS
Ophthalmic Surgeon, Epworth Freemasons Hospital, Melbourne, Victoria, Australia

Anne-Maree Kelly, MBBS MD MClinEd FACEM FCCP
Director, Joseph Epstein Centre for Emergency Medicine Research, Western Health, Melbourne; Professorial Fellow, Joseph Epstein Centre for Emergency Medicine Research, Western Health, St Albans, Victoria; Department of Medicine, Melbourne Medical School – Western Precinct, The University of Melbourne, St. Albans, Victoria; Adjunct Professor, School of Public Health, Queensland University of Technology, Brisbane, Queensland, Australia

Marcus Kennedy, MBBS FACEM FRACGP DA (UK) DipIMC (RCSEd) MHlth ServMt GAICD
Director, Adult Retrieval Victoria, Melbourne, Victoria, Australia

Zeff Koutsogiannis, MBBS FACEM GCert Clin Tox
Emergency Physician & Clinical Toxicologist, Austin Health & Victorian Poison Information Centre, Melbourne, Victoria, Australia

Erica Kreismann, MD FACEM
Director & Staff Specialist in Emergency Medicine, Calvary Hospital, Lenah Valley, Tasmania; Specialist in Aeromedical and Retrieval Medicine, Ambulance Tasmania, Hobart, Tasmania, Australia

Win Sen Kuan, MBBS MRCSEd (A&E) MCI FAMS
Senior Consultant, Emergency Medicine Department, National University Hospital, Singapore; Assistant Professor, Department of Surgery, Yong Loo Lin School of Medicine, National University of Singapore, Singapore

Rohan Laging, MBBS (Hons) FACEM
Emergency Physician, Emergency and Trauma Centre, The Alfred Hospital, Melbourne; Clinical Director Emergency Department, Cabrini Hospital, Melbourne, Victoria, Australia

Yit Hung Leang, MBBS FACEM PGDip (Med.Tox.)
Emergency Physician & Clinical Toxicology Fellow, Austin Health & Victorian Poison Information Centre, Melbourne, Victoria, Australia

Francis Chun-Yue Lee, MBBS (S'pore) FRCSEd (A&E) FAMS
Senior Consultant, Acute & Emergency Care Centre, Khoo Teck Puat Hospital, Singapore; Adjunct Associate Professor, Lee Kong Chian School of Medicine; Adjunct Assistant Professor, Yong Loo Lin School for Medicine

Marian Lee, MBBS DCH FACEM MHA
Emergency Physician, Prince of Wales Hospital, Sydney, New South Wales, Australia

David Lightfoot, BSc (Med) MBBS FACEM
Emergency Physician, Monash Medical Centre, Monash Health, Melbourne, Victoria, Australia

Mark Little, MBBS FACEM MPH&TM DTM&H IDHA
Emergency Physician and Clinical Toxicologist, Department of Emergency Medicine, Cairns Hospital, Cairns, Queensland, Australia; Clinical Toxicologist, New South Wales Poisons Information Service, New South Wales, Australia

Jason Long, MBChB FRCEM FRCP DRTM DipMedEd
Dean, Royal College of Emergency Medicine, London; Consultant in Emergency Medicine, Queen Elizabeth University Hospital, Glasgow, United Kingdom

Carl Luckhoff, MBChB FACEM GCEH (Aeromed)
Emergency Physician, The Alfred Emergency and Trauma Centre, Alfred Health, Melbourne, Victoria, Australia

William Lukin, MBBS FACEM FAChPM
Senior Staff Specialist, Emergency Department, Royal Brisbane and Women's Hospital, Brisbane; Staff Specialist in Palliative Care, Metro North Hospital and Health Service, Brisbane, Queensland, Australia

Brett Lurie, MBBS BSc (Med) RANZCR
Staff Specialist Radiologist, Royal North Shore Hospital, Sydney, New South Wales, Australia

Gerard McCarthy, MBBCh BAO FRCSI FRCSEd (A&E) FRCEM
Consultant in Emergency Medicine, Cork University Hospital, Cork; Clinical Lead, National Emergency Medicine Programme, Clinical Strategy and Programmes Division, Health Service Executive, Dublin, Ireland

David McCoubrie, MBBS FACEM
Emergency Physician and Clinical Toxicologist, Royal Perth Hospital, Perth; VMO Clinical Toxicologist, New South Wales Poisons Information Centre, The Children's Hospital at Westmead, Sydney, New South Wales, Australia

C. Geraldine McMahon, MB BAO BCh BSCAnat FRCSEd FRCPI FRCEM PhD
Professor of Emergency Medicine, Trinity College, Dublin; Clinical Associate, St. James's Hospital, Dublin, Ireland

Andrew Maclean, MBBS FACEM
Director of Emergency Services, Box Hill Hospital, Melbourne; Adjunct Senior Lecturer, Eastern Health Clinical School, Monash University Faculty of Medicine, Melbourne, Victoria, Australia

Amit Maini, MBBS BSc FACEM
Emergency Physician, The Alfred Hospital, Melbourne; Adjunct Senior Lecturer, Monash University, Melbourne, Victoria, Australia

Sander Manders, MD FACEM FRCEM
Emergency Physician, Royal Darwin Hospital, Darwin; Medical Retrieval Consultant, CareFlight, Darwin, Northern Territory, Australia

Gopi Mann, MBChB MSc(MedTox) FACEM
Emergency Physician & Clinical Toxicologist, Western Sydney Health, NSW; Clinical Toxicologist, NSW Poisons Information Centre, Sydney, New South Wales, Australia

Desmond Mao, MBBS MCEM MMed (Emergency Medicine)
Consultant, Acute and Emergency Care Department, Khoo Teck Puat Hospital, Singapore

Paul D. Mark, MBBS FACEM GAICD AFCHSM Grad Cert HSM
Area Director Clinical Services, South Metropolitan Health Service, Perth; Clinical Associate Professor of Emergency Medicine, University of Western Australia, Perth; Adjunct Associate Professor, School of Health Sciences, Curtin University, Perth, Western Australia, Australia

Alex Markwell, BSc MBBS (Hons) FACEM
Senior Staff Specialist, Emergency and Trauma Centre, Royal Brisbane and Women's Hospital, Brisbane; Senior Lecturer, University of Queensland, Brisbane, Queensland, Australia

Adam Michael, MBBS(Hons) BSc(Hons) JCCA FACEM
Staff Specialist, Department of Emergency Medicine, Bundaberg Hospital, Bundaberg, Queensland, Australia

Biswadev Mitra, MBBS MHSM PhD FACEM
Emergency Physician, Alfred Hospital Emergency and Trauma Centre, Melbourne; Professor, Critical Care Research, Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Victoria, Australia

Satish Mitter, MBBS DipTox FACEM
Emergency Physician & Clinical Toxicologist, Western Sydney Health, NSW; Clinical Toxicologist, NSW Poisons Information Centre, Sydney, New South Wales, Australia

Vanessa Morgan, MBBS FACD
Consultant Dermatologist, The Royal Melbourne Hospital, Melbourne; Consultant Dermatologist, Royal Children's Hospital, Melbourne; Consultant Dermatologist/Mohs surgeon, Skin and Cancer Foundation, Melbourne, Victoria, Australia

Mark Morphett, BAppSci (Physio) MBBS (Hons) FACEM
Emergency Physician, Co-Director of Emergency Medicine Training, Flinders Medical Centre, Adelaide, South Australia, Australia

David Mountain, MBBS FACEM
Adjunct Associate Professor, Academic Emergency Medicine Department, University of Western Australia School of Medicine, Perth; Staff specialist, Emergency Department, Sir Charles Gairdner Hospital, Perth, Western Australia, Australia

Kellie Muir, MA BSW BA
Family Violence Project Coordinator, Alfred Health, Melbourne, Victoria, Australia

Adrian Murphy, MB MRCS FFSEM FRCEM PhD
Consultant in Emergency Medicine, Mercy University Hospital and Cork University Hospital, Cork; Senior Lecturer in Emergency Medicine, University College Cork, Cork, Ireland

Gayathri Devi Nadarajan, MBBS (London) MRCEM (UK) MMed (Emergency Medicine)
Associate Consultant, Department of Emergency Medicine, Singapore General Hospital, Singapore

Marcus Ong Eng Hock, MBBS MPH
Department of Emergency Medicine, Singapore General Hospital; Professor, Health Services and Systems Research, Duke-National University of Singapore Medical School, Singapore

Kenneth Ooi, MBBS FACEM
Emergency Physician, Epworth Richmond, Richmond, Victoria, Australia

Shirley Ooi, MBBS FRCSEd (A&E) MHPE FAMS
Senior Consultant, Emergency Medicine Department, National University Hospital; Designated Institutional Official, National University Health System Residency Program; Associate Professor, Department of Surgery, Yong Loo Lin School of Medicine, National University of Singapore, Singapore

Francis O'Keeffe, MB BCh BAO BA Mod(Biochem) FRCEM FACEM
Consultant in Emergency Medicine, Mater Misericordiae University Hospital, Dublin, Ireland

Gerard O'Reilly, MBBS FACEM PhD MPH MBiostat
Emergency Physician, Emergency and Trauma Centre, The Alfred Hospital, Melbourne; Adjunct Clinical Associate Professor, Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Victoria, Australia

Íomhar O'Sullivan, FRCEM MRCPI FRCSEd
Consultant in Emergency Medicine, Cork University, Cork, Ireland

Debbie Paltridge, BappSc (Phty) MHSc (Ed)
Education Consultant, Director Health Education Innovative Solutions, Carindale, Queensland, Australia

Michelle C. Papandony, MBBS (Hons) FRACP
Consultant Rheumatologist, Department of Rheumatology, The Alfred Hospital, Melbourne, Victoria, Australia

John Pasco, MBBS FACEM
Director of Emergency Services, Werribee Mercy Hospital, Werribee, Victoria, Australia

Sameer A. Pathan, MD PhD
Consultant and Vice Chair Research, Emergency Medicine Department, Hamad General Hospital, Hamad Medical Corporation, Doha, Qatar; Department of Epidemiology & Preventive Medicine, Monash University, Melbourne, Victoria, Australia

Peter Pereira, MBBS FACEM
Senior Emergency Physician, The Cairns Hospital, Cairns, Queensland, Australia

Georgina Phillips, MBBS FACEM
Emergency Physician, St Vincent's Hospital, Melbourne; Senior Lecturer and Honorary Fellow, The University of Melbourne, Melbourne, Victoria, Australia

Grant Phillips, BA Grad Dip Bus (Man) Grad Dip (MHN) M (Nurs) MACMHN
Senior Clinician, CATT, St Vincent's Hospital, Melbourne, Victoria, Australia

David Pilcher, MBBS MRCP (UK) FRACP FCICM
Intensive Care Specialist, The Alfred Hospital, Melbourne; Chairman, The Australian and New Zealand Intensive Care Society (ANZICS) Centre for Outcome and Resources Evaluation; Adjunct Clinical Professor, The Australian and New Zealand Intensive Care Research Centre, School of Public Health and Preventive Medicine, Monash University, Melbourne; Medical Advisor to Donate Life in Victoria, Australia

Stephen Priestley, MBBS FACEM
Senior Staff Specialist in Emergency Medicine, Sunshine Coast Hospital and Health Service, Queensland, Australia

Mark Putland, MBBS FACEM
Director of Emergency Medicine, Royal Melbourne Hospital, Parkville, Victoria, Australia

Mohan Raghavan, MBBS FACEM
Emergency Physician and Clinical Toxicologist, Royal Perth Hospital, Perth; Clinical Toxicologist, WA poisons Information centre, Perth, Western Australia, Australia

Fatima Rahman, MBCHB FACEM
Director Emergency Department Sandringham, Deputy Director Emergency Services Alfred Health; Emergency Physician, Alfred Health, Melbourne, Victoria, Australia

Timothy H. Rainer, MD
Professor of Emergency Medicine, Cardiff University School of Medicine, Cardiff, United Kingdom

Shammi Ramlakhan, MBBS MBA PGCert(T&L) FRCSEd FRCEM
Senior Lecturer, The University of the West Indies, St Augustine, Trinidad & Tobago; Honorary Consultant, Emergency Department, San Fernando Teaching Hospital, Trinidad & Tobago; Consultant Emergency Physician, Sheffield Children's Hospital, Sheffield, United Kingdom

Drew Richardson, BMedSc MBBS (Hons) FACEM GradCertHE MD
Chair of Road Trauma and Emergency Medicine, Australian National University Medical School, Canberra; Senior Staff Specialist, Emergency Department, Canberra Hospital and Health Services, Canberra, Australian Capital Territory, Australia

James Rippey, MBBS FACEM DCH DDU
Emergency Physician, Sir Charles Gairdner Hospital, Perth, Western Australia, Australia

Darren M. Roberts, MBBS PhD FRACP
Staff Specialist, Clinical Pharmacology/Toxicology and Nephrology, St Vincent's Hospital, Sydney; Clinical Toxicologist, New South Wales Poisons Information Centre, The Children's Hospital at Westmead, Sydney; Conjoint Associate Professor, University of New South Wales, Sydney, New South Wales, Australia

Karen Robins-Browne, MBBS FACEM DCH
Emergency Physician, Barwon Health, Geelong, Victoria, Australia

Eileen M. Rogan, MBBS FACEM PhD
Director and Staff Specialist, Emergency Department, Canterbury Hospital, Sydney, New South Wales, Australia

Ian Rogers, MBBS FACEM
Emergency Physician, St John of God Murdoch Hospital, Perth; Professor of Emergency Medicine, University of Notre Dame, Fremantle, Western Australia, Australia

Joe-Anthony Rotella, BSc MBBS FACEM
Clinical Toxicology Fellow, Victorian Poisons Information Centre and Austin Toxicology Service, Austin Health, Melbourne; Emergency Physician, Austin Health, Melbourne, Victoria, Australia

Melanie Rule, BSc MBBS (Hons) FACEM
Senior Staff Specialist, Emergency Department, The Prince Charles Hospital, Brisbane; Senior Lecturer, The University of Queensland, Brisbane, Queensland, Australia

John M. Ryan, FRCEM FRCSEd (A&E) FFSEM DCH DipSportsMed
Consultant in Emergency Medicine, St Vincent's University Hospital, Dublin, Ireland

Mark Salter, BSc MBBS (Hons) FACEM
Emergency Physician and Honorary Clinical Toxicology Fellow, Nepean Hospital, Kingswood, New South Wales; Department of Clinical Pharmacology and Toxicology, Western Sydney Health, New South Wales, Australia

Jamie Seymour, BSc (Hon) PhD
Associate Professor, Queensland Tropical Health Alliance, James Cook University, Cairns, Queensland, Australia

Andrew Singer, AM MBBS FACEM FIFEM
Adjunct Associate Professor, Australian National University Medical School, Acton; Senior Specialist in Emergency and Retrieval Medicine, Canberra Hospital and Health Services, Garran; Principal Medical Adviser, Australian Government Department of Health, Canberra, Australian Capital Territory, Australia

David R. Smart, BMedSci MBBS (Hons) MD (UTas) FACEM FIFEM FUHM FAICD FACTM DipDHM DipAdvDHM (ANZCA)
Clinical Professor, University of Tasmania, Hobart; Medical Codirector, Department of Diving and Hyperbaric Medicine, Royal Hobart Hospital, Hobart, Tasmania, Australia

De Villiers Smit, MBChB FACEM
Director, Alfred Health Emergency, Emergency & Trauma Centre, Alfred Health, Melbourne, Victoria, Australia

Catherine Smith, MAdvSW (Research) BSW
Allied Health Team Leader, Senior Social Worker, Alfred Health, Melbourne; Senior Clinician-Family Violence, Social Work Department, Alfred Health, Melbourne, Victoria, Australia

Jessamine Soderstrom, MBBS FACEM Grad Cert Clin Tox
Clinical Toxicologist, Emergency Physician, Royal Perth Hospital, Perth; Clinical Senior Lecturer, University of Western Australia, Perth, Western Australia, Australia

Annabel Somerville, MBBS FACEM MPH&TM
Emergency Physician, Cairns Hospital, Queensland, Australia

Swithin Song, MBBS FRANZCR
Radiologist, Royal Perth Hospital, Perth, Western Australia, Australia

David Spain, MBBS FRACGP FACEM
Bachelor of Medicine and Bachelor of Surgery, Fellow Australasian College for Emergency Medicine, Fellow Royal Australian College of General Practitioners; Deputy Director Emergency Medicine, Gold Coast University Hospital, Southport; Adjunct Fellow Menzies Institute of Health, Griffith University, Southport; Associate Professor of Medicine, Bond University, Robina, Queensland, Australia

John C. Spencer, MBBS FACEM
Emergency Physician, Alfred Health, Melbourne, Victoria, Australia

Peter Sprivulis, MBBS PhD
Emergency Physician, Fiona Stanley Hospital, Perth, Australia, Fremantle Hospital, Fremantle, Western Australia, Australia

Helen E. Stergiou, MBBS FACEM
Emergency Physician, Alfred Health, Melbourne, Victoria, Australia

Jeremy Stevens, MBBS FACEM
Emergency Physician, Alfred Health, Melbourne, Victoria, Australia

Evan Symons, MBBS/BA M.Psychiatry FRANZCP
Unit Head, Consultation-Liaison & Emergency Psychiatry, Alfred Health, Melbourne, Victoria, Australia

R.C. Andrew Symons, MBBS PhD FRANZCO
Ophthalmic Surgeon, Royal Melbourne Hospital, Melbourne; Head of Ophthalmology, Department of Surgery, The University of Melbourne, Melbourne, Victoria, Australia

Gim Tan, MBBS FACEM
Senior Emergency and Trauma Physician, The Alfred, Melbourne, Adjunct Senior Lecturer, Department of Epidemiology and Preventive Medicine, School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia

David McD. Taylor, MBBS MD MPH DRCOG FACEM
Director of Emergency Medicine Research, Austin Health, Melbourne, Victoria, Australia

Jane Terris, MBChB MSc FRCP FRCEM FACEM
Consultant in Emergency Medicine, Sheffield Childrens' and Rotherham NHS Foundation Trusts, Sheffield

Graeme Thomson, MBBS MBA FACEM
Director of Emergency Medicine, Angilss Hospital, Melbourne, Victoria, Australia

Gino Toncich, MBBS FACEM MBA Dip Anaes (UK)
Emergency Physician, Royal Melbourne Hospital, Melbourne; Honorary Senior Lecturer in Medicine, Melbourne University, Melbourne, Victoria, Australia

Greg Treston, BMedSci MBBS (Tas) DTMH (Lon) DIMCRCS (Ed) FACEM FACRRM
Director, Emergency Department, Mater Hospital Brisbane, Brisbane, Queensland, Australia

Steven Troupakis, MBBS DipRACOG FACEM
Emergency Physician, Monash Health, Melbourne, Victoria, Australia

Stacy Turner, MBChB, FACEM, FRCEM
Emergency Physician, Western Health, Melbourne, Victoria, Australia

Hilary Tyler, MBChB MBBS FACEM
Emergency Physician, Alice Spring Hospital, Alice Springs, Northern Territory, Australia

Anthony Tzannes, MBBS FACEM FCICM
Emergency and Intensive Care Physician, Rockingham General Hospital, Perth, Western Australia, Australia

George Varigos, MBBS FACD PhD
Specialist Dermatologist, Hospital, Melbourne; Honorary Clinical Professor of Medicine, University of Melbourne, Melbourne, Victoria, Australia

Kiran Veera, MBBS FACEM
Emergency Physician and Co-DEMT, Department of Emergency Medicine, Bendigo Health, Bendigo, Victoria, Australia

John Vinen, MBBS MHP FACEM FIFEM FACBS
Emergency Physician & Medicolegal Consultant, Kingsford, New South Wales, Australia

Ioana Vlad, MD FACEM
Emergency Medicine Physician and Clinical Toxicologist, Sir Charles Gairdner Hospital, Perth, Western Australia, Australia

Katie Walker, MBChB Dip DHM FACEM
Director of Emergency Medicine Research, Emergency Department, Cabrini, Melbourne; Adjunct Clinical Associate Professor, Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Victoria, Australia

Mark J. Walland, MBBS FRANZCO FRACS
Ophthalmic Surgeon, Royal Victorian Eye and Ear Hospital, Melbourne, Victoria, Australia

Nicola Walsham, MB BS (Hons) FACEM DTMH PGCert Med Tox
Emergency Physician, Royal Melbourne Hospital, Melbourne, Victoria, Australia

Matthew Warden, MBBS FRANZCP MRCPsych
Psychiatrist and Director, Acute Psychiatric Inpatient Services, St Vincent's Hospital, Melbourne; Teaching Fellow, The University of Melbourne, Melbourne, Victoria, Australia

Alan Watts, MB BCh BAO Dip IMC (RCSEd) FRCEM
Consultant in Emergency Medicine, University Hospital Limerick, Limerick, Ireland

Ben White, LLB Hons (QUT) DPhil (Oxf)
Professor, Australian Centre for Health Law Research, Queensland University of Technology, Brisbane, Queensland, Australia

Julian White, MBBS MD
Clinical Toxinologist & Head of Toxinology, Women's & Children's Hospital, Adelaide, South Australia, Australia

Garry Wilkes, MBBS FACEM
Director, Emergency Medicine, Bass Coast Health, Wonthaggi; Clinical Associate Professor, School of Surgery, University of Western Australia, Perth, Western Australia, Australia

Anselm Wong, MBBS DipTox PhD FACEM FACMT
Associate Professor, Centre for Integrated Critical Care, University of Melbourne; Emergency Physician and Clinical Toxicologist, Victorian Poisons Information Centre, Austin Health, Victoria, Australia School of Clinical Sciences at Monash Health, Monash University, Victoria, Australia

Kim Yates, MBChB MMedSc PGDipClinEd FACEM
Emergency Medicine Specialist, Director of Emergency Medicine Research, North Shore & Waitakere Emergency Departments, Waitematā District Health Board, Auckland, New Zealand; Honorary Senior Lecturer, Centre for Medical & Health Services Education, University of Auckland, New Zealand

Anusch Yazdani, MBBS FRANZCOG CREI
Associate Professor of Gynaecology, University of Queensland, Brisbane; Director, QFG Research Foundation, Brisbane, Queensland, Australia

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Introduction

It is hard to imagine an efficient, safe and accessible system of emergency care that is not underpinned by the specialty of emergency medicine. Although the systems of emergency care vary in maturity in different countries, there is consensus that having skilled and dedicated staff at the 'front door' of the hospital significantly improves outcomes and improves efficiency in the system.

Definition

Emergency medicine is defined by the International Federation for Emergency Medicine (IFEM) as 'a field of practice based on the knowledge and skills required for the prevention, diagnosis and management of acute and urgent aspects of illness and injury affecting patients of all age groups with a full spectrum of episodic undifferentiated physical and behavioural disorders; it further encompasses an understanding of the development of pre-hospital and in-hospital emergency medical systems and the skills necessary for this development'.

This definition is deliberately broad and encompasses both the pre-hospital and in-hospital domains of practice. It is important to note that, in many countries, elements of emergency medicine are practised under other specialties, such as anaesthesia, general practice and internal medicine. There is a strong belief among emergency physicians that, although there will always be a crossover between different specialty training, the emergency medical system will be optimized only by having a strong cadre of physicians trained specifically to provide emergency care available 24 hours every day.

The Franco-German model of emergency care has traditionally involved doctors in the prehospital sphere initiating resuscitation and assessment and then transporting the patient directly to inpatient services (without a formal emergency department). This model of care is becoming more difficult to sustain as inpatient services become more specialized and a greater emphasis is placed on early diagnosis, treatment and discharge. Many patients with potentially complex presentations can be fully 'packaged' within hours of arrival and discharged home. The idea of a consultant/professorial ward round the following day is difficult to justify. Equally, when patients arrive in hospital and are inadequately assessed and placed on the wrong clinical pathway, there are dangers for the patient and inefficiencies in the system.

Development of emergency medicine

In many ways, emergency medicine is the foundation of modern medicine. Going back to ancient times, patients were forced to seek the help of a physician for emergencies, such as wound management, and painful conditions, such as renal colic. Approaches to some of these conditions were quite sophisticated, even in ancient Egyptian and Chinese societies. However, there was little attention to systems of care and final outcomes were literally in the hands of the gods.

War—although a terrible thing—can have some positive influences. From Napoleonic times, it became evident that casualties could be better managed by triaging patients—identifying those most likely to live and identifying life-threatening injuries. In the last century, the First and Second World Wars saw huge improvements in the organization of the emergency response to injured soldiers. However, it was not until the Vietnam/American war that we saw a huge change in the way medical services responded to war casualties. With helicopter transport and well-organized paramedics, scene times were reduced to minutes and times to definitive surgery were shortened. Surgeons returning from duty on the war front realized that civilian practice in major urban centres was lagging behind services offered on the front line and set about improving response to civilian trauma.

At the same time, major improvements in medical practice meant that access to technology and skills, delivered quickly, could save lives. Examples included cardiac arrest, trauma, and sepsis. Prior to the 1950s, there were few time-dependent treatments that actually changed the final outcome for most patients.

A further influence on the development of medical systems was the transfer of industrial processes from the factory to the hospital. The lessons learnt in industry showed that if processes could be standardized with clear pathways and reduced variation, quality could be improved and costs reduced. The idea of the friendly doctor who knew his/her patients and everything that happened to them became a thing of the past. Hospitals changed from a 'cottage industry' to a 'factory' model. Emergency medicine, when it is performed well, ensures that patients are received, assessed and treated in a standardized fashion, 24 hours/day, 7 days/week. The necessity for emergency specialists to manage this system is clear. Putting patients on the wrong 'conveyor belt' of management because of poorly trained staff in the initial assessment period can have a devastating impact on outcome and lead to major inefficiencies in the hospital.

A final influence on the development of emergency medicine is the problem of worsening access to emergency care across the Western world. It is clear that demand for emergency care has risen at the same time that hospital bed numbers have been reduced. Governments have tried to make the best use of limited bedstock by reducing 'inappropriate' admissions and reducing length of stay. In good emergency medical systems, only those patients who are unable to be managed as outpatients will be admitted. In addition, patients will receive the right treatment from skilled practitioners at the earliest possible time. Realization of the importance of skilled practitioners to direct emergency patient management around the clock has led to a massive global investment in emergency medicine.

A functioning emergency medical care system helps to ensure a more robust response during natural and humanitarian disasters. The World Health Organization has recognized this more recently and promoted the development of basic emergency training and facilities in lower- and middle-income countries. Previously, the specialty of emergency medicine was viewed as an expensive addition to basic medical care—now it is seen as a fundamental structure to enable an adequate response to disasters.

Scope of practice

The fact that emergency physicians have general training which can act as a foundation for many subspecialties has led to a large variation in practice around the world—according to local needs and skills. There are core diagnostic and resuscitation skills that should be common to all emergency doctors. However, depending on practice location, some physicians may become more expert in specific skills because of need. For example, in many underdeveloped countries, expertise in obstetrics is essential, including the ability to perform a caesarean section. Drugs and alcohol will be very important in some inner-city emergency departments, whereas geriatrics may be more important in other locations. The basic skills of an emergency physician remain the same; identifying life/limb-threatening issues immediately, then prioritizing, diagnosing and treating other conditions before discharging home or admitting to an inpatient team. Finally, an emergency physician must coordinate the clinical team and the system to ensure optimal outcomes for the patient.

Emergency medicine now has a large number of subspecialties, including toxicology, paediatrics, trauma, critical care, prehospital/disaster medicine, sports medicine, hyperbaric medicine, academic emergency medicine and many more. There are now 1- to 2-year fellowships available in most of these disciplines. However, it is important that every emergency physician has a basic grounding in these subspecialties so that, when confronted with the unexpected, they feel comfortable managing the situation. Having subspecialist skills is important in large departments with many specialists, so that there are expert resource people to develop the clinical service as a whole.

The future

Emergency medicine is a specialty that has arisen from the evolution of medical care from cottage industry to a system of care based on industrial processes. This is not static and is likely to change even more dramatically into the future. It is certain that the work pattern of an emergency specialist going forward, will be very different. Changes to diagnostics, therapeutic modalities, patient demographics and the work pattern of our medical colleagues will all have an impact on what emergency medicine practice entails. Patient expectations regarding service delivery are also changing, with greater emphasis on shared decision making, timely access to care and physician accountability.

There are potential threats to the quality of emergency medical care delivered, such as overly burdensome time-based key performance indicators, used indiscriminately to meet government targets. Overcrowding has made life difficult to practice good care in many emergency departments and government changes to funding arrangements have served to deny poor people access to emergency care. These potential threats and others may also represent further opportunities to streamline care and improve interaction with colleagues in acute management and demand advocacy on the part of emergency physicians. Despite these threats, there is an underlying strength in our specialty—the ability to provide the best care to undifferentiated emergency patients 24 hours/day, 7 days/week. If we focus on our core business, the specialty will continue to grow and remain a central pillar of the overall medical system.

SECTION 1

RESUSCITATION

Edited by *Conor Deasy*

1.1 Basic life support

Sameer A. Pathan

ESSENTIALS

1 A patient with sudden out-of-hospital cardiac arrest (OHCA) requires activation of the Chain of Survival, which includes early high-quality cardiopulmonary resuscitation (CPR) and early defibrillation. The emergency medical dispatcher plays a crucial and central role in this process.

2 Over telephone, the dispatcher should provide instructions for external chest compressions only CPR to any adult caller wishing to aid a victim of OHCA. This approach has shown absolute survival benefit and improved rates of bystander CPR.

3 In the out-of-hospital setting, bystanders should deliver chest compressions to any unresponsive patient with abnormal or absent breathing. Bystanders who are trained, able, and willing to give rescue breaths should do so without compromising the main focus on high quality of chest compressions.

4 Early defibrillation should be regarded as part of Basic Life Support (BLS) training, as it is essential to terminate ventricular fibrillation.

5 There is strong emphasis on the implementation of public-access defibrillation programs, which include the use of automated external defibrillators by untrained or minimally trained lay rescuers in public areas.

Introduction

Basic Life Support (BLS) aims to maintain respirations and circulation in the cardiac arrest victim. BLS's major focus is on CPR with minimal use of ancillary equipment. It includes chest compressions with or without rescue breathing and defibrillation with a manual or automated external defibrillator (AED). BLS can be successfully performed immediately by any rescuer with little or no prior training or experience using dispatcher-assisted telephone instructions in the OHCA. BLS has proven value in aiding the survival of neurologically intact victims.[1–3]

This chapter outlines an approach to BLS that can be delivered by any rescuer while awaiting the arrival of emergency medical services (EMS) or medical expertise able to provide Advanced Life Support (ALS) (see Chapter 1.2).

Chain of Survival

The Chain of Survival is the series of linked actions taken in treating a victim of sudden cardiac arrest.[4] The first steps are early recognition of an individual at risk of or in active cardiac arrest and an immediate call to activate help from EMS. This is followed by early commencement of CPR with an emphasis on high-quality chest compressions and rapid defibrillation, which significantly improves the chances of survival from ventricular fibrillation (VF) in OHCA.[1–3] CPR plus defibrillation within 3 to 5 minutes of collapse following VF in OHCA can produce survival rates as high as 49% to 75%.[5–7] Each minute of delay before defibrillation reduces the probability of survival to hospital discharge by 10% to 12%.[2,3] The final links in the Chain of Survival are effective ALS and integrated post-resuscitation care targeted at optimizing and preserving cardiac and cerebral function.[8]

Development of protocols

Any guidelines for BLS must be evidence based and consistent across a wide range of providers. Many countries have established national committees to advise community groups, ambulance services and the medical profession of appropriate BLS guidelines. Box 1.1.1 lists the national associations that make up the International Liaison Committee on Resuscitation (ILCOR). The ILCOR group meets every 5 years to review the BLS and ALS guidelines and to evaluate the scientific evidence that may lead to changes.

Box 1.1.1 Membership of the International Liaison Committee on Resuscitation 2015

American Heart Association (AHA)
European Resuscitation Council (ERC)
Heart and Stroke Foundation of Canada (HSFC)
Resuscitation Council of Southern Africa (RCSA)
Australian and New Zealand Committee on Resuscitation (ANZCOR)
InterAmerican Heart Foundation (IAHF)
Resuscitation Council of Asia (RCA)

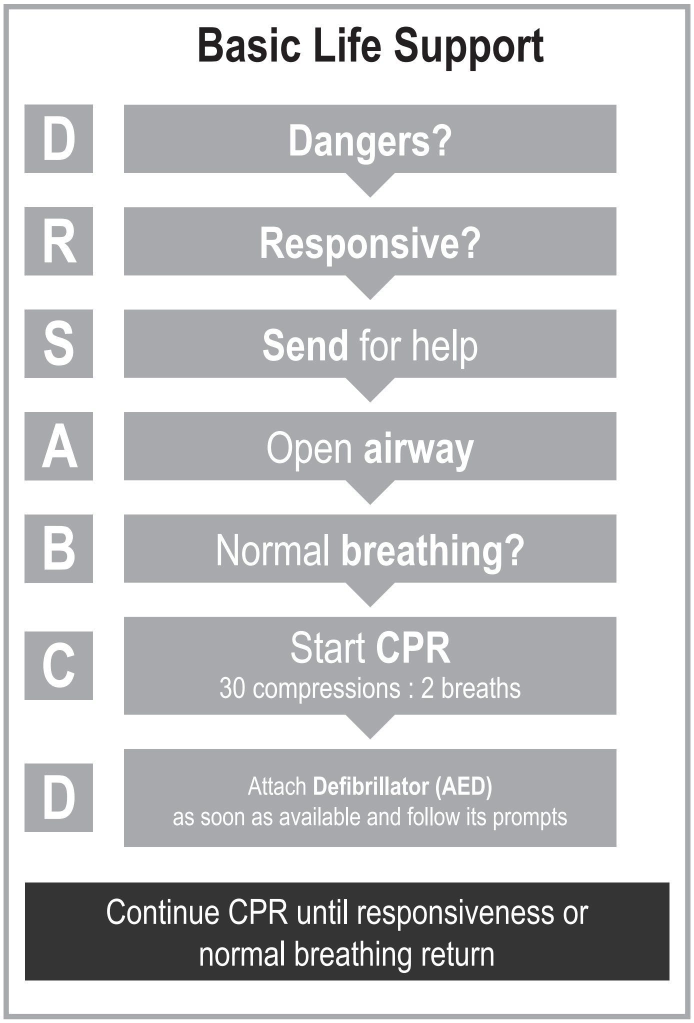

FIG. 1.1.1 Australian Resuscitation Council and New Zealand Resuscitation Council Basic Life Support flowchart. *AED*, Automated external defibrillator; *CPR*, cardiopulmonary resuscitation. (Reproduced from https://resus.org.au/guidelines/flowcharts-3/)

Revision of the Basic Life Support guidelines, 2015

The most recent revision of the BLS guidelines occurred in 2015 and followed a comprehensive evaluation of the scientific literature for each aspect of BLS. Evidence evaluation worksheets were developed and were then considered by ILCOR (available at http://circ.ahajournals.org/content/132/16_suppl_1/S40). The final recommendations were published in late 2015.[8]

Australian Resuscitation Council and New Zealand Resuscitation Council Basic Life Support guidelines

Each national committee endorsed the guidelines with minor regional variations to take into account local practices. The recommendations of the Australian Resuscitation Council (ARC) combined with those of the New Zealand Resuscitation Council (NZRC) on BLS were published jointly in 2016 and are available at http://www.resus.org.au/policy/guidelines/ and http://www.nzrc.org.nz/guidelines/ respectively.

DRSABCD approach to Basic Life Support

A flowchart for the initial evaluation and provision of BLS for the collapsed patient is shown in Fig. 1.1.1. This is based on a DRSABCD approach, the letters of which stand for *D*angers? *R*esponsive? *S*end for help; open *A*irway; normal *B*reathing? start *C*PR; and attach *D*efibrillator. This process therefore includes the recognition that a patient has collapsed and is unresponsive, a safe approach to checking for danger and immediately sending for help to activate the emergency medical response team. This is followed by opening the airway and briefly checking for abnormal or absent breathing, with rapid commencement of chest compressions and rescue breaths if the pulse is absent. A defibrillator is attached as soon as it is available, and prompts are followed if it is automatic or semiautomatic.

Change to the adult Basic Life Support in 2015

A significant change to the adult BLS in the ILCOR 2010 resuscitation guidelines was the recommendation for a Compressions, Airway, Breathing (CAB) sequence instead of an Airway, Breathing, Compressions (ABC) sequence. This was aimed at minimizing any delay in initiating chest compressions, particularly when the sudden collapse is witnessed and likely of cardiac origin. In the 2015 guidelines, the ILCOR task force differed from regional resuscitation councils in deciding to use the CAB or ABC sequence, as limited literature exists to make any single recommendation.

Regional variations

There are regional variations in the interpretation and incorporation of opening the airway within the BLS algorithm. In the European Resuscitation Council (ERC) and the ARC with the NZRC algorithm, opening the airway comes before assessment of breathing followed by compression if required. This effectively preserves the ABC sequence to avoid confusion, whereas the American Heart Association (AHA) Resuscitation Guidelines 2015 continue to advise a CAB sequence for CPR.

The ILCOR 2015 universal BLS algorithm with ARC and NZRC considerations is discussed in the remainder of this chapter.

Check for response and send for help

The patient who has collapsed is rapidly assessed to determine whether he or she is unresponsive and not breathing normally, indicating possible cardiorespiratory arrest. For an untrained rescuer, this can be sequentially assessed by a gentle 'shake and shout' and observation of the patient's response rather than by looking specifically for signs of life (which was deemed potentially confusing). The rescuer can then assess the unresponsive patient for absent or inadequate breathing.

If cardiac arrest is assumed, the rescuer should immediately telephone the EMS *(call first)* and initiate chest compressions as advised by the dispatcher to initiate BLS care. A trained rescuer or health care provider may check for unresponsiveness and abnormal breathing at the same time and then activate the EMS or cardiac arrest team.

The health care rescuers may commence CPR with ventilation for approximately 2 minutes before calling the EMS *(CPR first)* when the collapse is due to suspected airway obstruction (choking) or inadequate ventilation (drowning, hanging, etc.) or for infants and children up to 18 years of age.

Assessment of airway and breathing

Make an assessment of the airway if a patient has collapsed and is apparently unconscious. Place the patient supine if face down and look for any signs of obvious airway obstruction. A trained lay rescuer or health care rescuer may open the airway using the head tilt–chin lift manoeuvre when assessing breathing or giving ventilations. Care should be taken not to move the patient's neck in the case of suspected trauma; however, the airway takes precedence over any injury.

Adequate respiration is assessed by visually inspecting the movement of the chest wall, whether it rises and falls, and listening for upper airway sounds. In cases of cardiac arrest, occasional deep respirations (agonal gasps) may continue for a few minutes after the initial collapse; these are not considered to represent normal breathing. In suspected foreign body obstruction, one can assess the severity of obstruction by effective cough in a conscious patient. If the initial assessment of an unconscious patient reveals adequate respiration the victim should be turned to the semi-prone or lateral recovery position, followed by constant checks to ensure continued respiration and the maintenance of breathing while awaiting the arrival of the EMS.

The current recommendation for an untrained lay rescuer is that he or she should not attempt to palpate for a pulse, as a pulse check is inaccurate in this setting.[8] A health care provider should take no more than 10 seconds to check for a pulse. If the rescuer does not definitely feel a pulse within 10 seconds, chest compressions should be started immediately.

Cardiopulmonary resuscitation

In the past, the BLS sequence of rescuer opening the airway, positioning the patient, retrieving a barrier or giving mouth-to-mouth expired air resuscitation (EAR) breaths as two initial 'rescue breaths' often delayed the chest compressions. These are also difficult and challenging for an untrained lay rescuer to implement and have resulted in significant delays or, worse still, no attempt at CPR at all. Therefore the current recommendation is to initiate CPR with immediate chest compressions if the patient is assumed to be in cardiac arrest.

Management

Chest compressions

All lay rescuers (trained or untrained) and health care rescuers should begin CPR by performing chest compressions on the lower half of the sternum on any adult in apparent cardiac arrest. The patient should be placed supine on a firm surface—such as a backboard, hard mattress, or even the floor—to optimize the effectiveness of the chest compressions. There is strong emphasis on delivering high-quality chest compressions: rescuers should push hard to a depth of at least 5 cm (or 2 inches) at a rate of approximately 100 to 120 compressions per minute, allowing full chest recoil by avoiding leaning on the chest between the compressions and minimizing interruptions in the chest compressions.[8] Hence the maxim, '*Push hard, push fast, allow complete recoil and minimize interruptions*'. During BLS in the OHCA setting, there is insufficient evidence to support a pulse check while performing CPR. Therefore all attention should be paid to delivering high-quality CPR and noting any obvious change in the patient's response until the EMS arrives.

Cardiac or thoracic pump mechanism

There is ongoing debate as to whether external chest compressions generate blood flow via a 'cardiac' or a 'thoracic pump' mechanism. Whatever the predominant mechanism of blood flow, owing to the relative rigidity of the chest wall, chest compressions result in around 20% of normal cardiac output in the adult.

Chest compressions with ventilation

Rescuers willing, trained, and able to provide ventilation should give two rescue breaths after each 30 compressions, for a compression/ventilation ratio of 30/2. However, time to deliver two rescue breaths should be kept to 10 seconds or less, followed by immediate resumption of the chest compressions.

'Chest compression only' cardiopulmonary resuscitation

In the case of untrained rescuers, where rescuers are unable or unwilling to perform mouth-to-mouth breaths ('standard' CPR), 'compression only' CPR is recommended. This technique is also recommended for EMS dispatchers providing telephone advice to callers seeking to aid adults with suspected OHCA.

Health care professionals as well as lay rescuers are often uncomfortable giving mouth-to-mouth ventilation to an unknown victim of cardiac arrest. This should not, however, prevent them from carrying out at least 'hands-only' or 'chest compression–only' CPR, as bystander CPR has been shown to improve survival over no CPR at all.[9] The consensus on compression-only CPR compared with conventional CPR suggests no difference between the two methods in survival and favourable neurological or functional outcome in the short or long term.[10] Therefore to improve the likelihood of bystander CPR, compression-only CPR remains the recommended technique for the untrained rescuer or OHCA responder who is unable or unwilling to deliver rescue breaths.

Passive ventilation with chest recoil

The rationale for hands-only or chest compression–only CPR is that if the airway is open, passive ventilation may provide some gas exchange during the recoil phase of the chest compressions. However, the passive ventilation technique should not be considered an alternative to conventional CPR. The EMS responders may adopt the passive ventilation technique as part of a bundled intervention of care with free-flowing oxygen supply during a continuous high-quality chest compression phase.

Emergency medical services bundled intervention cardiopulmonary resuscitation care

In a broad definition, most EMS bundled interventions include 200 initial chest compressions followed by single shock and immediate resumption of next 200 chest compressions before a rhythm or pulse check. The rate of compressions remains 100 to 120 per minute and ventilation is achieved with bag-mask device at the rate of 8 per minute so as to minimize interruptions during compressions. Few EMS systems also use passive oxygen insufflation with basic airway adjunct and rely solely on passive ventilations during chest recoil. There is a growing literature in support of EMS bundled intervention as an alternative to conventional CPR for witnessed shockable OHCA.

Airway and breathing

The airway is opened using the head tilt–chin lift manoeuvre when assessing breathing or giving ventilations in an unresponsive adult or child. Solid material in the oropharynx should be removed with a careful sweep of a finger if inspection of the airway reveals visible foreign material or vomitus in the upper airway.

Foreign body airway obstruction

If a victim suspected of a foreign body airway obstruction (FBAO) can cough, he or she should be encouraged to cough and expel it out. If the cough is ineffective and the patient is conscious, he or she may be given up to five back blows with the heel of a hand and then up to five chest thrusts at the same compression point as in CPR, but sharper and slower. These techniques may be alternated, but it is also important to call for the EMS. If the victim becomes unresponsive, CPR may be started as described in Fig. 1.1.1.

Airway obstruction manoeuvres A number of manoeuvres have been proposed to clear the airway if it is completely obstructed by a foreign body. In many countries, abdominal thrusts are still endorsed as the technique of choice (i.e. the Heimlich manoeuvre). However, as this technique is associated with life-threatening complications, such as intra-abdominal injury, it is no longer recommended by the ARC or NZRC. Instead, the preferred technique for clearing an obstructed airway is by alternating back blows and/or chest thrusts.

Airway equipment

When cardiac arrest occurs in a medical facility, simple airway equipment may be used as an adjunct to EAR. This would include the use of a simple face mask or bag-valve-mask ventilation with or without an oropharyngeal Guedel airway. This equipment has the advantage of familiarity, it decreases the risk of cross-infection, is aesthetically more appealing and may deliver additional oxygen, but it does require prior training.[8]

Whichever technique of assisted ventilation is used, the adequacy of the tidal volume delivered over 1 second is assessed by a rise of the victim's chest. Current guidelines during adult cardiac arrest support the use of the highest possible percentage of inspired oxygen during CPR. However, any concentration of oxygen during CPR is acceptable, the aim being to use the maximum available concentration to correct tissue hypoxia.[8]

Defibrillation

As soon as a defibrillator is available, the electrode pads should be attached to the victim and the device switched on. Self-adhesive defibrillation pads have the practical advantages of being safe, convenient and effective; they are increasingly preferred over handheld paddles. In all cases, the safety of the rescuers and other team members remains paramount during the handling of defibrillators and shock delivery.

Shock delivery

When using an automated external defibrillator, the rescuer follows the voice instructions, such as 'stand clear' and 'press the button' to deliver the shock if indicated. When using a manual defibrillator, the health care rescuer must personally select the desired energy level and deliver a shock after recognizing a shockable rhythm (VF or pulseless ventricular tachycardia [VT]).

Minimizing interruptions to chest compressions Irrespective of the resultant rhythm, chest compressions must be resumed immediately after each shock to minimize the 'no-flow' time. The interruption during chest compressions, including the preshock interval (for rhythm analysis and shock delivery) and postshock interval (from shock delivery to resumption of compressions), should be no more than 10 seconds.

All modern defibrillators are now biphasic rather than monophasic and are more effective in terminating ventricular arrhythmias at lower energy levels. However, there is still no randomized study showing superiority in terms of neurological survival or survival to hospital discharge.

If a shock is not indicated, the rescuer should immediately resume CPR at a 30/2 compression/ventilation ratio and wait for EMS to arrive or for the victim to start responding.

Automated external defibrillator

The automated external defibrillator is now considered a part of BLS. AED devices are extremely accurate in diagnosing VF or VT. AEDs are simple, safe and effective when used by either lay rescuers or health care professionals (in or out of hospital).

Lay rescuer/nonmedical personnel and public-access automated external defibrillator

AEDs have been shown to be an effective part of the BLS program. Both ILCOR and ANZCOR strongly recommend implementation of public-access AED programs for patients with OHCA. AED use in public places such as airports, schools, sport facilities and recreation facilities by minimally trained rescuers, untrained rescuers, police officers or fire and disaster management first responders has achieved improved survival rates. Data from multiple observational, nationwide studies have shown improved rates of successful defibrillator use and chances of survival through public-access AED programs.

Home-access automated external defibrillator

Finally, an AED may be placed in the home of a patient who is at increased risk of sudden cardiac arrest (who does not have an implantable cardioverter-defibrillator [ICD]) for use by a relative who might witness the event. However, home-access AEDs are not associated with any improvement in survival rates. Therefore the use of such a device may be considered on an individual basis rather than as routine recommendation.

Implantable cardioverter defibrillator and cardiopulmonary resuscitation

Patients at highest immediate risk of unexpected cardiac arrest may have an ICD inserted which, on sensing a shockable rhythm, will discharge approximately 40 J through an internal pacing wire embedded in the right ventricle. Although most patients with an implanted defibrillator remain conscious during defibrillation, CPR should be commenced if the patient fails to respond to the ICD counter shocks and becomes unconscious. Intermittent firing of the implanted defibrillator presents no additional risk to bystanders or medical personnel. However, it is prudent to wear gloves and to minimize contact with the patient while the device is discharging.

Basic life support summary

The five links in the Chain of Survival for a patient with sudden cardiac arrest include the following:

- Immediate *recognition* of the emergency and *activation* of help from the EMS system
- Early *CPR* with an emphasis on chest compressions
- Earliest use of *defibrillation*
- Effective *ALS*
- Integrated *post-resuscitation care*

Cardiac arrest may be presumed if the adult victim is unresponsive and not breathing normally (ignoring occasional gasps) without assessing for a pulse. A trained rescuer may open the airway using the head tilt–chin lift manoeuvre as part of the breathing assessment, but the lay/untrained rescuer should waste no time in initiating chest compressions. Rescuers should activate the EMS system and start chest compressions immediately. If a lone health care rescuer responds to suspected asphyxia or respiratory-related cardiac arrest (e.g. immersion or drowning), it is still reasonable for the health care rescuer to provide 2 minutes of CPR before leaving the victim alone to activate EMS.

All rescuers, whether trained or not, should at least provide chest compressions to a victim of cardiac arrest, with a strong emphasis on delivering high-quality chest compressions. Trained rescuers should also provide two rescue breaths after each 30 chest compressions at a ratio of 30/2 and deliver five cycles of 2 minutes each. The compression rate should be approximately 100 to 120 per minute and a depth of at least 5 cm (or 2 inches). All BLS guidelines encourage the use of an AED by lay rescuers in cases of cardiac arrest, maintaining chest compressions while charging the defibrillator to minimize any pre-shock pause.

BLS care should be continued until advanced help arrives and takes over CPR, the victim starts to respond or begins breathing normally, it is impossible for the rescuer to continue CPR (e.g. exhaustion or safety compromise to rescuer) or a health care professional calls for the cessation of CPR.

CONTROVERSIES AND KNOWLEDGE GAPS

- CPR to follow ABC or CAB sequence initially
- Role of passive oxygenation and ventilation in compression only CPR
- EMS bundled intervention care in OHCA presenting in non-shockable rhythm
- Timing of CPR cycle and optimal interval for rhythm check
- Value of pulse check while performing CPR in BLS
- Role of real-time audiovisual feedback and prompt devices during CPR

References

1. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: the 'Chain of Survival' concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. *Circulation*. 1991;83(5):1832–1847.
2. 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Circulation*. 2015;132:S1–S311.
3. Sasson C, Rogers MA, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. *Circ Cardiovasc Qual Outcomes*. 2010;3(1):63–81.
4. Iwami T, Kawamura T, Hiraide A, et al. Effectiveness of bystander-initiated cardiac-only resuscitation for patients with out-of-hospital cardiac arrest. *Circulation*. 2007;116:2900–2907. https://doi.org/10.1161/CIRCULATIONAHA.107.723411.
5. Bobrow BJ, Spaite DW, Berg RA, et al. Chest compression-only CPR by lay rescuers and survival from out-of-hospital cardiac arrest. *JAMA*. 2010;304:1447–1454. https://doi.org/10.1001/jama.2010.1392.
6. Bobrow BJ, Ewy GA, Clark L, et al. Passive oxygen insufflation is superior to bag-valve-mask ventilation for witnessed ventricular fibrillation out-of-hospital cardiac arrest. *Ann Emerg Med*. 2009;54:656–662.e1. https://doi.org/10.1016/j.annemergmed.2009.06.011.
7. Bobrow BJ, Clark LL, Ewy GA, et al. Minimally interrupted cardiac resuscitation by emergency medical services for out-of-hospital cardiac arrest. *JAMA*. 2008;299:1158–1165. https://doi.org/10.1001/jama.299.10.1158.
8. Hoke RS, Heinroth K, Trappe HJ, Werdan K. Is external defibrillation an electric threat for bystanders? *Resuscitation*. 2009;80:395–401.
9. Mitani Y, Ohta K, Yodoya N, et al. Public access defibrillation improved the outcome after out-of-hospital cardiac arrest in school-age children: a nationwide, population-based, Utstein registry study in Japan. *Europace*. 2013;15:1259–1266. https://doi.org/10.1093/europace/eut053.
10. Weisfeldt ML, Sitlani CM, Ornato JP, et al. Survival after application of automatic external defibrillators before arrival of the emergency medical system: evaluation in the resuscitation outcomes consortium population of 21 million. *J Am Coll Cardiol*. 2010;55:1713–1720. https://doi.org/10.1016/j. jacc.2009.11.077.

1.2 Advanced life support

Sameer A. Pathan

ESSENTIALS

1 **Follow the Advanced Life Support (ALS) resuscitation guidelines developed by, or based on, those of the International Liaison Committee on Resuscitation (ILCOR).**

2 **Perform chest compressions without interruption for patients with no pulse, except when performing essential ALS interventions.**

3 **Deliver a shock to attempt defibrillation (150–200 joules [J] biphasic or 360 J monophasic) if the rhythm is either ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT).**

4 **Institute other ALS interventions as indicated.**

5 **Correct reversible causes of cardiac arrest—the '4 Hs and 4 Ts'.**

6 **Implement a comprehensive, structured post-resuscitation treatment protocol.**

Introduction

A patient in cardiac arrest represents the most time-critical medical crisis an emergency physician manages. The interventions of Basic Life Support (BLS) and Advanced Life Support (ALS) have the highest probability of success when applied immediately; they become less effective with the passage of time and, after only a short interval without treatment, are ineffectual.[1]

Larsen et al., in 1993, calculated the time intervals from collapse to the initiation of BLS, defibrillation, and other ALS treatments and analysed their effect on survival after out-of-hospital cardiac arrest. When all three interventions were immediately available, the survival rate was 67%. This figure declined by 2.3%/min of delay to BLS, by a further 1.1%/min of delay to defibrillation, and by 2.1%/min to other ALS interventions. Without treatment, the decline in survival rate is the sum of the three, or 5.5%/min.

Chain of Survival

The importance of rapid treatment for cardiac arrest led to the development of a systems management approach, represented by the concept of a 'Chain of Survival', which has become the accepted model for emergency medical services (EMS).[2] This concept implies that more people survive sudden cardiac arrest when a cluster or sequence of events is activated as rapidly as possible. The Chain of Survival includes the following:

- Early access to EMS and cardiac arrest prevention
- Early high-quality cardiopulmonary resuscitation (CPR)
- Early defibrillation
- Early advanced care and post-resuscitation care

All the links in the chain must connect, as weakness in any one reduces the probability of patient survival. ALS involves the continuation of BLS as necessary, but with the additional use basic or advanced airway devices, vascular access techniques, and the administration of pharmacological agents.

Aetiology and incidence of cardiac arrest

The commonest cause of sudden cardiac arrest in adults is ischaemic heart disease.[3] Other causes include respiratory failure, drug overdose, metabolic derangements, trauma, hypovolaemia, immersion and hypothermia.

The incidence of out-of-hospital cardiac arrest (OHCA) recorded in Aus-ROC Epistry was 102.5 cases per 100,000 population.[4] The crude incidence of OHCA in New Zealand was noted as 124 cases per 100,000 person-year. In both studies, 12% to 15% of cases with attempted resuscitation survived to hospital discharge or 30 days.

Advanced Life Support guidelines and algorithms

The most clinically relevant advance in ALS, over the last two decades has been the substantial simplification of the management of cardiac arrest by the development of widely accepted universal guidelines and algorithms that include evidence-based recommendations.

International Liaison Committee on Resuscitation

In Chapter 1.1, Box 1.1.1 shows the national associations that formed the International Liaison Committee on Resuscitation (ILCOR) in 1993. The ILCOR group used to meet every 5 years to review the best available scientific literature and to publish the Consensus on Cardiopulmonary

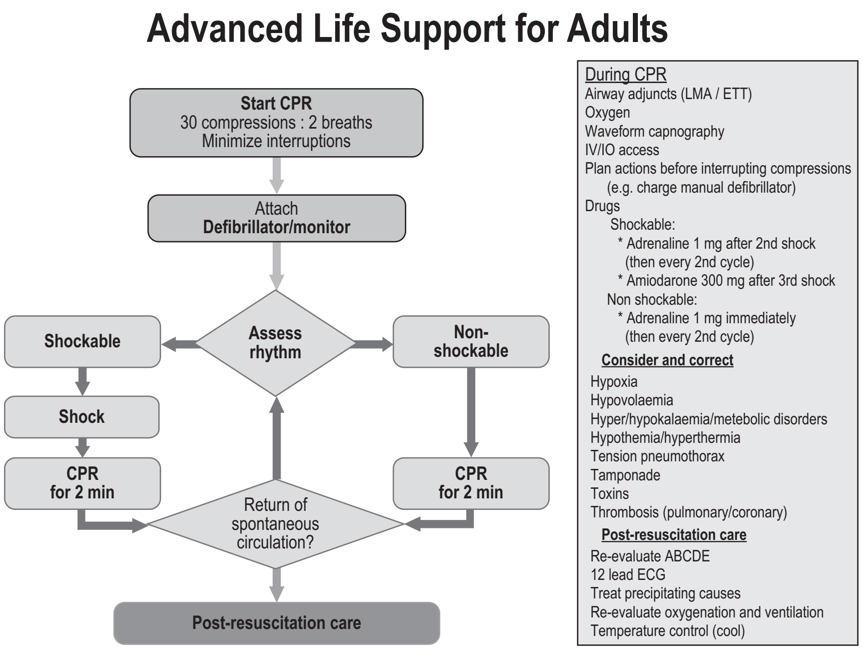

FIG. 1.2.1 Algorithm for the management of adult cardiorespiratory arrest. (Reproduced from https://resus.org.au/guidelines/flowcharts-3/)

Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations (CoSTR). However, ILCOR realized the potential drawbacks of this approach in terms of delays in the implementation of new effective treatments. Since 2016, therefore, ILCOR has adopted the new procedure of publishing annual ILCOR CoSTR summary articles so as to provide a nearly continuous review of resuscitation science. The conference held in Dallas in February 2015 gave rise to the CoSTR documents published later that year.

Australasian guidelines and algorithms

Each ILCOR member body is expected to use the CoSTR documents to develop its own guidelines for local use. The Australian Resuscitation Council (ARC) and the New Zealand Resuscitation Council (NZRC) released joint Australasian guidelines in 2016; these are available at http://www.resus.org.au/policy/guidelines/ and http://www.nzrc.org.nz/guidelines/ respectively. The Australasian guidelines include an Adult Cardiorespiratory Arrest algorithm (Fig. 1.2.1) that is clear, concise and easy to memorize and adapt into poster format. It is also readily applied clinically. This algorithm provides the framework used throughout this chapter to discuss ALS interventions.

However, resuscitation knowledge is still incomplete and many ALS techniques currently in use are not supported by the highest levels of scientific evidence. Thus strict adherence to any guideline should be informed by common sense. Individuals with specialist knowledge may modify practice according to the level of their expertise and the specific clinical situation or environment in which they practice.

Initiation of Advanced Life Support

The purpose of BLS is to support the patient's cardiorespiratory status as effectively as possible until equipment—particularly a defibrillator—and advanced treatment support become available. High-quality CPR remains the cornerstone of both BLS and ALS. The vast majority of cardiac arrest survivors have ventricular fibrillation (VF) as the primary rhythm, and electrical defibrillation is fundamental to the successful treatment for VF and pulseless ventricular tachycardia (VT). Therefore the likelihood of defibrillation restoring a sustained, perfusing cardiac rhythm and of a favourable long-term outcome greatly depends on good CPR and decreasing the time to defibrillation. The chances of survival to hospital discharge decline rapidly after as little as 90 seconds of cardiac arrest.

The point of entry into the ALS algorithm depends on the circumstances of the cardiac arrest. In situations where there are multiple rescuers, BLS should be initiated or continued while the defibrillator-monitor is being prepared. For a single rescuer who witnesses cardiac arrest in a setting where a defibrillator-monitor is readily available, it is a reasonable approach to obtain and attach the defibrillator immediately without commencing BLS. In all other cases, there is low-quality evidence suggesting that a brief period (1.5–3 minutes) of CPR before defibrillation may improve survival in patients where the cardiac arrest is unwitnessed or time to get a defibrillator is more than 4 to 5 minutes from arrest time.

Automated Chest Compression Devices

Load-distributing band and piston devices as well as the Lund University Cardiac Arrest System (LUCAS) are commonly used automated chest compression devices (ACCDs). Moderate-quality evidence has shown uncertainties regarding the benefits or harms of ACCDs over manual compressions.[5] Therefore ILCORs suggest against the routine use of ACCDs to replace manual chest compressions. An ACCD can be used as an alternative where manual compressions are impractical or may compromise a provider's safety, as in a moving ambulance, CPR in limited space or fewer personnel available for CPR.

Attachment of the defibrillator-monitor and rhythm recognition

Automated external defibrillator

Apply the self-adhesive pads in the standard anteroapical positions for defibrillation (see further on) when using an automated external defibrillator (AED). An internal microprocessor analyses the electrocardiographic (ECG) signal and, if VF/VT is detected, the AED displays a warning and then either delivers a shock (automatic) or advises the operator to do so (semiautomatic).

Manual external defibrillator

In manual defibrillation, after applying the self-adhesive pads or handheld paddles of an external defibrillator, the rescuer must determine whether or not the cardiac rhythm is VF/VT.

Rhythm recognition

Ventricular fibrillation

VF is a pulseless, chaotic, disorganized rhythm characterized by an undulating, irregular pattern that varies in amplitude and morphology, with a ventricular waveform of more than 150/min.

Pulseless ventricular tachycardia

Pulseless VT is characterized by broad, bizarrely shaped ventricular complexes associated with no detectable cardiac output. The rate is more than 100/min by definition and is usually in excess of 150.

Asystole

Asystole is identified by the absence of any electrical cardiac activity on the monitor. Occasionally it is incorrectly diagnosed ('apparent asystole') on the ECG monitor because

- The ECG lead may be disconnected or broken. Look for the presence of electrical artefact waves on the monitor during external chest compression, indicating that the ECG leads are connected and intact. A perfectly straight line suggests lead disconnection or breakage.
- Lead sensitivity may be inappropriate. Increase the sensitivity setting to maximum. The resulting increase in the size of electrical artefact will confirm that the sensitivity selection is functioning.
- VF has a predominant axis. Even coarse VF may cause minimal undulation in the baseline if the axis is at right angles to the selected monitor lead and thus resembles asystole. Select at least two leads in succession before asystole is diagnosed, preferably leads at right angles, such as II and aVL.

Pulseless electrical activity/ electromechanical dissociation

The absence of a detectable cardiac output in the presence of a coordinated electrical rhythm is called pulseless electrical activity (PEA), also known as electromechanical dissociation (EMD). Use of an arterial line in place, monitoring of end-tidal carbon dioxide ($ETCO_2$) or point-of-care cardiac ultrasound can help to differentiate between a true PEA and a pseudo-PEA. In general PEA has a poor outcome compared with shockable rhythms and there is some evidence regarding true PEA having a worse outcome than pseudo-PEA.[6] In an observational study of OHCA and patients with PEA, an electrical frequency of greater than 60/min compared with the frequency of less than 60/min showed better 30-day survival rate (22%) and good neurological outcome (in 15%) – comparable to with shockable cardiac arrest.

Defibrillation

The only proven effective treatment for VF and pulseless VT is early electrical defibrillation. The defibrillator must immediately be brought to the person in cardiac arrest and, if the rhythm is VF/VT, a shock must be delivered without delay.

Anteroapical pad or paddle position

There are two accepted positions for the defibrillation pads or paddles to optimize the delivery of current to the heart. The most common is the anteroapical position: one pad/paddle is placed to the right of the sternum just below the clavicle and the other is centred lateral to the normal cardiac apex in the anterior or midaxillary line (V5–6 position).

Anteroposterior pad or paddle position

An alternative is the anteroposterior position: the anterior pad/paddle is placed over the precordium or apex and the posterior pad/paddle is placed on the patient's back to the left or right of the spine at the level of the lower scapula or even in the interscapular region.

Do *not* attempt defibrillation over ECG electrodes or medicated patches and avoid placing pads/paddles over significant breast tissue in females. Also, the pads/paddles should be placed at least 8 cm away from the module and pulse generator, if the patient has an implanted pacemaker or a cardioverter-defibrillator. Arrange to check the function of any pacemaker or cardioverter-defibrillator as soon as practicable after successful defibrillation.

Waveform and energy of shocks

Two main types of waveform are available from cardiac defibrillators.

Biphasic waveforms

All modern defibrillators use biphasic waveforms with impedance compensation; this is now considered the 'gold standard'. Biphasic (bidirectional) truncated transthoracic shock defibrillators are effective at lower energies and result in fewer ECG abnormalities after defibrillation.

Set the energy level at 150 to 200 J or follow the manufacturer's advice if using a biphasic defibrillator in an adult with VF/pulseless VT cardiac arrest. For subsequent shocks, if the defibrillator is capable of increasing energy, it is reasonable to do so.

Monophasic sinusoidal waveform

Old defibrillators use a damped monophasic sinusoidal waveform, which is a single pulse lasting for 3 to 4 ms. Set the energy level at the maximum when using a monophasic defibrillator in adults, which is usually 360 J for all shockable rhythms in cardiac arrest.

Optimizing transthoracic impedance

A critical myocardial mass must be depolarized synchronously for defibrillation to be successful. This interrupts the fibrillation and allows recapture by a single pacemaker. The transthoracic impedance must be minimized for the greatest probability of success.

Reduction of transthoracic impedance

- Use pads/paddles 10 to 13 cm in diameter for adults. Smaller paddles/pads allow too concentrated a discharge of energy, which may cause focal myocardial damage. Larger pads/paddles do not make good chest contact over their entire area and/or may allow current to be conducted through non-myocardial tissue.
- Use conductive pads or electrode paste/gel. This reduces impedance by 30%. Take care to ensure that there is no electrical contact between the pads or paddles, either directly or through electrode paste, as this will result in current arcing across the chest wall.
- Apply a pressure of 5 to 8 kg to the paddle when adhesive pads are not being used.
- Perform defibrillation when the chest is deflated (i.e. in expiration).
- However, routine use of impedance thoracic device in addition to conventional CPR is discouraged.

Current-based defibrillation

Conventional defibrillators are designed to deliver a specified amount of energy measured in joules. Depolarization of myocardial tissue is accomplished by the passage of electrical current through the heart; clinical studies have determined that the optimal current is 30 to 40 amps (A). The current delivered at a fixed energy is inversely related to the transthoracic impedance, so a standard energy dose of 200 J delivers about 30 A to the average patient.

Some newer current-based defibrillators automatically measure transthoracic impedance and then predict and adjust the energy delivered to avoid an inappropriately high or low transmyocardial current. These devices have defibrillation success rates comparable to those of conventional defibrillators while cumulatively delivering less energy. The reduced energy should result in less myocardial damage and may reduce post-defibrillation complications.

Automated external defibrillators

Automated external defibrillators (AEDs) were first introduced in 1979 and have become standard equipment in EMS systems for use outside hospital, as well as in many areas within hospital. EMS systems equipped with AEDs are able to deliver the first shock up to 1 minute faster than when a conventional defibrillator is used. Rates of survival to hospital discharge are equivalent to those achieved when more highly trained first responders use manual defibrillators.[2]

The major advantage of AEDs over manual defibrillators is their simplicity, which reduces the time and expense of initial training and continuing education and increases the number of persons who can operate the device.[2] Members of the public have been trained to use AEDs in a variety of community settings and have demonstrated that they can retain these skills for up to a year.[2] Encouraging results have been produced when AEDs have been placed with community responders, such as firefighters, police officers, casino staff, security guards at large public assemblies, and public transport vehicle crews.[2]

The Australasian College for Emergency Medicine recommends that all clinical staff in health care settings should have rapid access to an AED or a defibrillator with AED capability.

Delivering a shock

If the rhythm is assessed as shockable (VF or pulseless VT), the defibrillator should be charged while CPR continues. Then, after health care personnel are clear of the patient, a single shock is delivered. Following this shock, CPR should be recommenced *immediately* without any delay to assess or analyse either the pulse or the rhythm.

If the resuscitation team leader is uncertain whether the rhythm is shockable or non-shockable, no shock should be given.

Three stacked shocks

In 2010, the ILCOR recommended single-shock delivery for cardiac arrest patients with a shockable rhythm. Since 2010 no study has shown that any specific shock strategy is of benefit for survival, return of spontaneous circulation (ROSC) or recurrence of VF outcomes. However, keeping in mind the significance of minimal interruptions to chest compressions in improving survival outcomes, the 2015 CoSTR by ILCOR recommends single-shock delivery for all cases of cardiac arrest with shockable rhythm.

In a witnessed and monitored cardiac arrest with VF/VT, if the time to deliver shock is less than 20 seconds and time to rhythm check and recharge the defibrillator is less than 10 seconds, a sequence of up to three stacked shocks can be considered. This may be applicable to a patient who develops witnessed cardiac arrest while connected to a defibrillator with monitoring capability in a prehospital, emergency department (ED), critical care unit, coronary care unit or operation theatres.

Technical problems

Whenever attempted defibrillation is not accompanied by skeletal muscle contraction, take care to ensure good contact and that the defibrillator is turned on, charged up, develops sufficient power and is not in synchronized mode. The operational status of defibrillators should be checked regularly, and a standby machine should be available at all times. The majority of defibrillator problems are due to operator error or faulty care and maintenance.

Complications of defibrillation

- Skin burns may occur; these are usually superficial and can be minimized by ensuring optimal contact between the defibrillator pad/paddle and the patient.
- Myocardial injury and post-defibrillation dysrhythmias may occur with cumulative high-energy shocks.
- Skeletal muscle injury or thoracic vertebral fractures are possible, albeit rare.
- Electrical injury to the health care provider may occur as a result of contact with the patient during defibrillation. These range from paraesthesia to deep partial-thickness burns and cardiac arrest. The defibrillator operator must ensure that all rescue personnel are clear of the patient before delivering a shock.
- Also ensure that the patient, rescuers, and equipment are dry before defibrillation is attempted in wet conditions, such as outdoors or around a swimming pool area.

CPR 'code Blue' process

Shockable rhythms

Immediate defibrillation is essential for VF/pulseless VT, although periods of well-performed CPR help maintain myocardial and cerebral viability and may improve the likelihood of success with subsequent shocks. After delivering a single shock, CPR should be resumed immediately and continued for 2 minutes unless the patient becomes responsive and resumes normal breathing.

The rationale for continuing the CPR cycle immediately after shock is that there is typically a delay of several seconds before a diagnostic-quality ECG trace is obtained. Additionally, even when defibrillation is successful, there is temporary impairment of cardiac function from seconds to minutes, associated with a weak or impalpable pulse. Thus waiting for a recognizable ECG rhythm or palpating for a pulse that may not be present—even after successful defibrillation—unnecessarily delays the recommencement of CPR. This is detrimental to the patient who does not yet have ROSC.

At the conclusion of this period of CPR, reassess the ECG rhythm and, when appropriate, the pulse. Give a single shock without delay if VF/pulseless VT persists. Chest compressions should continue while the defibrillator is charging, and the scene is assessed for safe conditions to deliver the shock. This strategy is recommended to minimize 'no flow' time.

Non-shockable rhythms

When PEA or asystole is present on ECG rhythm and/or pulse assessment, do not defibrillate, as this may be deleterious. The prognosis for these conditions is much worse than for VF/VT and, unless there is potentially a reversible cause, the application of other ALS interventions (see further on) is indicated but seldom of value.

Cardiac pacing does *not* improve survival from asystole, either pre-hospital or in the ED setting.

Algorithm loops

Either continuously or during each 2-minute CPR cycle of the algorithm, give attention to the following:

- Minimize interruption to chest compressions during ALS interventions by planning and confirm their utility before attempting them.
- Administer 100% oxygen when available.
- Attempt to secure an advanced airway/ventilation technique but do not interrupt CPR for more than 20 seconds.
- Use waveform capnography to confirm airway placement and monitor the adequacy of CPR.
- Obtain vascular access.
- Administer adrenaline every second loop (i.e. every 4–5 minutes).
- Administer other drugs or electrolytes as indicated for individual circumstances.
- Correct potentially reversible conditions that may have precipitated the cardiac arrest and/or reduced the chances of successful resuscitation. These are listed in Fig. 1.2.1 and are conveniently remembered with the 4 Hs and 4 Ts.

The 4 Hs

Hypoxaemia
Hypovolaemia
Hyper-/hypokalaemia/other electrolyte or Hydrogen ion disorders
Hypo-/hyperthermia

The 4Ts

Tension pneumothorax
Tamponade (Cardiac)
Toxins, poisons, drugs
Thrombosis: pulmonary or coronary

Even the best-trained team will be unable to complete all of these management aspects within a single loop of the algorithm, but further opportunity will present itself if subsequent cycles are necessary.

Advanced airway management

Endotracheal intubation is considered the optimal method of airway management during cardiac arrest, with accompanied risk of complications such as oesophageal intubation if performed without adequate training and experience. Other alternative airway devices commonly used during CPR include the laryngeal mask airway (LMA), i-gel supraglottic airway, laryngeal tubes and the oesophageal-tracheal Combitube. There is insufficient evidence to support the preference of any single advance airway device over others or over basic airway management with a bag-mask device. Therefore choice of airway should be based on the equipment available, the circumstances of the cardiac arrest and the training and experience of the health care provider. Either an advance airway device or bag-mask device is an acceptable choice during cardiac arrest in any setting.

Endotracheal intubation

When a sufficiently experienced person is available, tracheal intubation should be performed provided that it does not interfere with or impede the CPR process. Laryngoscopy should be carried out during chest compressions with a strong recommendation that only a short interruption in chest compressions, not exceeding 20 seconds, should be permitted for insertion of tracheal tube between the cords.

Once the tube has been inserted, correct placement must be verified by seeing the tube pass between the cords, clinical observation of chest rise/fall and auscultation as well as, importantly, an exhaled carbon dioxide detector, such as a waveform capnograph.

The main benefit of an advanced airway, such as endotracheal intubation, is that no interruption to chest compressions is then necessary for ventilations during CPR. Also, an endotracheal tube isolates and protects the airway, allows suction and facilitates ventilation.

Ventilation and oxygenation

Cardiac arrest and CPR cause an increase in dead space and a reduction in lung compliance, thus compromising gas exchange. Therefore a fractional inspired oxygen concentration (FIO_2) of 1.0 (100% oxygen delivery system) is essential in cardiac arrest to maximize oxygen delivery.

Minute volume

Carbon dioxide (CO_2) production and delivery to the pulmonary circulation are limited by the markedly reduced cardiac output achieved during CPR. As a consequence, a relatively low minute volume of 3.5 to 5.0 L is sufficient to achieve adequate CO_2 excretion and prevent hypercapnia. This situation will be altered if a CO_2-producing buffer, such as sodium bicarbonate, is administered. A small increase in minute ventilation is then required to prevent the development of a respiratory acidosis.[1]

Ventilation rate and tidal volume

A ventilation rate of 8 to 10/min without pausing during chest compressions and a tidal volume of 400 to 500 mL (5–6 mL/kg) are sufficient to clear CO_2 during most cardiac arrest situations when an advanced airway is in place. This should cause a visible rise and fall of the patient's chest.

Vascular access and drug delivery

Intravenous route

The ideal route of drug delivery should combine rapid and easy vascular access with quick delivery to the central circulation. The intravenous route is preferred. This is most easily performed by inserting a cannula into a large vein in the upper limb or into the external jugular vein. Avoid lower limb veins because of their poor venous return from below the diaphragm during CPR as well as immediate or inexperienced central line insertion, which can have fatal consequences, such as pneumothorax or arterial laceration.

Drug delivery

Give a 20 to 30 mL IV fluid flush following any drug administered and/or raise the limb to facilitate delivery to the central circulation. A central venous cannula delivers drugs rapidly to the central circulation and should be used when already in place. Otherwise, insertion of a cannula during CPR requires time and technical proficiency and interferes with defibrillation and the CPR process; this, of course, is unacceptable.

Intraosseous route

The intraosseous route is also acceptable for drug delivery in adults as well as children. Suitable sites of insertion include above the medial malleolus or the proximal tibia. Practice is needed to perfect the technique, usually with a semiautomatic, handheld drill device.

Intratracheal route

The intratracheal instillation of drugs is an alternative during CPR, especially when tracheal intubation precedes venous access. Adrenaline, lignocaine and atropine may be safely administered through the endotracheal tube if there is a delay in achieving vascular access, although their efficacy is unproven (as it is for all ALS drugs by any route).

The ideal dose and dilution of drugs given by this route are unknown, but using 3 to 10 times the standard intravenous drug dose diluted in 10 mL of water or normal saline is recommended. The drug should be delivered via a catheter or quill placed beyond the tip of the endotracheal tube and followed by ventilations to aid dispersion.

Fluid therapy

Crystalloid solutions are used for the intravenous delivery of drugs during CPR. Glucose-containing solutions are avoided during CPR as they may contribute to post-arrest hyperglycaemia, which reduces or impairs cerebral recovery.

Drug therapy in Advanced Life Support

Not one drug used in resuscitation has been shown to improve long-term survival in humans after cardiac arrest. Despite this, a number of agents are employed based on theoretical, retrospective, or low-quality evidence of their efficacy.[1]

Adrenaline (epinephrine)

The putative beneficial actions of adrenaline in cardiac arrest relate to its alpha-adrenergic effects, which result in an increased aortic blood pressure as well as increased perfusion of the cerebral and coronary vascular beds and reduced blood flow to splanchnic and limb vessels. Adrenaline is considered the 'standard' vasopressor in cardiac arrest.[1] In observational studies, adrenaline was shown to improve short-term outcomes such as ROSC and admission to hospital; however, in clinical trials it had no effect on survival to discharge and was associated with poor neurological outcome, questioning its routine use in cardiac arrest.

Indications

- VF/pulseless VT when there is no ROSC after initial attempts at defibrillation.
- Asystole and PEA as initial treatment and then during every second loop thereafter.

Adverse effects

- Tachyarrhythmias
- Severe hypertension after ROSC
- Tissue necrosis after extravasation
- Poor neurological outcomes in longterm

Dosage

The standard adult dose is 1 mg IV q 4 to 5 minutes. Higher doses have not been shown to improve long-term outcome.

Amiodarone

Amiodarone has some benefit in survival to hospital admission refractory VF/VT in the setting of out-of-hospital cardiac arrest.[1] However, none of the anti-arrhythmics have shown to consistently result in improved survival to hospital discharge or favourable neurologic outcomes when compared to placebo.[9] The CoSTR 2015 recommendations suggest the use of amiodarone in adults with refractory VF/pVT to improve rates of ROSC.[1]

Indications

- Persistent VF/pulseless VT during the third loop following failed defibrillation and adrenaline administration
- Prophylaxis of recurrent VF/VT

Adverse effects

- Hypotension, bradycardia, heart block, QTc prolongation with proarrhythmic effects

Dosage

The initial bolus of amiodarone is 300 mg or 5 mg/kg, followed by a further 150 mg if necessary.

Atropine

Atropine has no consistent benefits in cardiac arrest and is no longer recommended for routine use in asystole/PEA.

Calcium

Calcium is indicated only when the cardiac arrest is caused or exacerbated by the conditions listed here:

Indications

- Hyperkalaemia
- Hypocalcaemia
- Poisoning by calcium-channel blocking drugs

Adverse effects

- Increase in myocardial and cerebral injury mediated by cell death
- Tissue necrosis with extravasation

Dosage

The initial dose is 5 to 10 mL of 10% calcium chloride or 15 to 30 mL of 10% calcium gluconate (three times the volume of calcium chloride for the equivalent cation dose).

Lignocaine (lidocaine)

The antiarrhythmic properties of lignocaine in cardiac arrest are known. In the Bayesian network meta-analysis published after CoSTR 2015 recommendations, lignocaine was found to be more effective than amiodarone as an effective anti-arrhythmic agent for survival to hospital discharge in patients with VF.[10]

Indications

- VF/pulseless VT refractory to defibrillation and adrenaline when amiodarone cannot be used.
- Prophylaxis of recurrent VF or VT.

Adverse effects

- Hypotension, bradycardia, heart block, asystole
- Central nervous system (CNS) excitation with anxiety, tremor and convulsions, followed by CNS depression with coma

Dosage

The initial dose is 1 to 1.5 mg/kg with an additional bolus of 0.5 mg/kg after 5 to 10 minutes if indicated.

Magnesium

Magnesium is indicated when the cardiac arrest is caused or exacerbated by the conditions listed here. There is no support for its routine use at present.

Indications

- Torsades de pointes (polymorphic VT). This is often associated with a prolonged QT interval due to ischaemia, electrolyte disturbances and drugs.
- Hypokalaemia.
- Hypomagnesaemia.
- Digoxin toxicity.
- Cardiac arrest due to VF/VT refractory to defibrillation and adrenaline.

Adverse effects

- Muscle weakness and paralysis if excessive quantities are administered

Dosage

The initial dose is a 5-mmol bolus (1.25 g or 2.5 mL of a 49.3% solution), repeated if indicated, and followed by an infusion of 20 mmol (5 g or 10 mL of a 49.3% solution) over 4 hours.

Potassium

Potassium is indicated only when the cardiac arrest is caused or exacerbated by the conditions listed here. There is no support for its routine use in cardiac arrest.

Indication

- Hypokalaemia

Adverse effects

- Hyperkalaemia with attendant dysrhythmias
- Extravasation may cause tissue necrosis

Dosage

A bolus of 5 mmol of potassium is given intravenously.

Sodium bicarbonate

Sodium bicarbonate is indicated only when the cardiac arrest is caused or exacerbated by the conditions listed here. There is no support for its routine use in cardiac arrest.

Indications

- Hyperkalaemia
- Poisoning by tricyclic antidepressants
- Severe metabolic acidosis
- Protracted cardiac arrest beyond 15 minutes

Adverse effects

- Metabolic alkalosis, hypernatraemia, hyperosmolality
- Production of CO_2 causing paradoxical intracellular acidosis, which may in part be ameliorated by adequate ventilation in CPR

Dosage

The initial dose is 1 mmol/kg (1 mL/kg of 8.4% sodium bicarbonate) over 2 to 3 minutes, then as guided by the arterial blood gases.

Vasopressin

Vasopressin is an alternative vasopressor to adrenaline. There is currently insufficient evidence to support its routine use either alone or in combination with adrenaline in any cardiac arrest rhythm.

Consider administration for:

- Vasopressor effect as an alternative to adrenaline

Adverse effects

- Cerebral oedema or haemorrhage after ROSC
- Persistent vasoconstriction following ROSC, which may exacerbate myocardial ischaemia and interfere with left ventricular function
- Procoagulant effect on platelets

Dosage

The dose is a single bolus of 40 U IV administered once during the episode of cardiac arrest.

Hemodynamic monitoring during CPR

End-tidal carbon dioxide

Animal and clinical studies indicate that measuring $ETco_2$ is effective and informative for determining progress during CPR, particularly if there is ROSC.

$ETco_2$ typically falls to less than 10 mmHg at the onset of cardiac arrest. It can rise to between one-quarter and one-third of the normal level with effective CPR and rises to normal or supranormal levels over the next minute following ROSC. A value of 10 mmHg or greater after tracheal intubation or 20 mmHg or greater after 20 minutes of CPR may be a predictor of survival to discharge. However, the $ETco_2$ cut-off value alone should not be used to predict mortality or to stop CPR.

Arterial blood gases

Arterial blood gas (ABG) monitoring during cardiac arrest is used as an indicator of oxygenation and the adequacy of ventilation but is not an accurate measure of tissue acidosis. An increase in $Paco_2$ may indicate improved tissue perfusion during CPR or with ROSC, if ventilation is constant. The measurement of ABGs should never interfere with the overall performance of good CPR.

Post-resuscitation care

This is covered in detail elsewhere but is mentioned here too as successful ROSC is only the first step in recovery from cardiac arrest. The post-cardiac arrest syndrome—comprising brain injury, myocardial dysfunction, a systemic ischaemia/reperfusion response and persistence of the causative pathology—often complicates the post-resuscitation phase. Among patients surviving to intensive care unit (ICU) admission but subsequently dying in hospital, brain injury is the cause of death in 68% after out-of-hospital cardiac arrest and in 23% after in-hospital cardiac arrest.

Implementation of a comprehensive, structured post-resuscitation treatment protocol may improve survival in cardiac arrest victims after ROSC. The most important elements of such a protocol are summarized in the following algorithm for adult ALS management (see Fig 1.2.1):

- Targeted temperature management (TTM; select and maintain between 32°C and 36°C), and treatment of hyperpyrexia
- Optimized airway management including advanced airway techniques in patients requiring continued ventilation
- Maintenance of normocapnoea and an arterial oxygen saturation of 94% to 98%
- Circulatory support to maintain tissue perfusion
- Control of seizures
- Control of blood glucose at 10 mmol/L or less but avoiding hypoglycaemia
- Treatment of any underlying cause of the cardiac arrest, in particular coronary reperfusion for myocardial ischaemia

Extracorporeal CPR

Limited data exist related to the use of ECPR in cardiac arrest. Observational studies have shown that the use of ECPR improved survival with good functional outcomes at 30 and 180 days, both in IHCA and OHCA. However, these observations were subject to selection bias. Therefore ANZCOR suggests that in patients with cardiac arrest not responding to standard CPR, it is reasonable to use ECPR as a rescue therapy for selected patients in settings capable of implementing it. ECPR can be used as bridging therapy for patients in cardiac arrest requiring percutaneous coronary intervention.

Futile resuscitation with prolonged CPR

The vast majority of patients who survive out-of-hospital cardiac arrest have ROSC before arrival at the ED. Only 33 of 5444 patients (0.6%) in 18 studies between 1981 and 1995 who were transported to an ED still in cardiac arrest after unsuccessful prehospital resuscitation survived to hospital discharge. Twenty-four of the surviving patients arrived in the ED in VF and 11 of these had their initial cardiac arrest in the ambulance en route to the hospital or had temporary ROSC before arrival.

Terminating resuscitative efforts before hospitalization

A range of recommendations with varying degrees of evidence are available to guide the decision to terminate CPR.[11] However, the termination of resuscitative efforts may be considered if *all* of the following criteria apply to a normothermic adult with OHCA:

1. Unwitnessed out-of-hospital cardiac arrest
2. No AED shocks delivered
3. No bystander CPR delivered
4. Primary arrest condition does not achieve ROSC within 25 minutes following standard ALS

In-hospital cardiac arrest with a poor outcome

A poor outcome is linked to pre-existing conditions, such as cardiogenic shock, metastatic cancer, renal failure, sepsis and an acute cerebrovascular accident. Age alone is not an independent predictor of outcome for either in-hospital or out-of-hospital cardiac arrest.

Outcome of prolonged Advanced Life Support

ALS resuscitation efforts lasting more than 30 minutes without ROSC at any stage are so uniformly unsuccessful that resuscitation should be abandoned, except in certain special circumstances, such as hypothermia, possibly some drug overdoses and following thrombolysis in suspected massive pulmonary embolism (PE). The return of spontaneous circulation at any time during the resuscitation process resets the clock time to zero.

Prognosis for survival after cardiac arrest

The best prospect of neurologically intact long-term survival after a cardiac arrest exists when

- The victim's collapse is witnessed.
- CPR is commenced immediately.
- Cardiac rhythm is VF or pulseless VT.
- Defibrillation is performed as soon as possible, ideally within 2 to 3 minutes of collapse.

CONTROVERSIES

- Acceptance of a universal algorithm
- Lack of a demonstrated role for any drug used in ALS
- Timing and dose for initial epinephrine in shockable rhythm
- Use of automated chest compression devices
- Role of ECPR in cardiac arrest management
- Amiodarone versus lidocaine in persistent VF arrest
- Criteria for the termination of CPR

References

1. Nolan JP, Hazinski MF, Aickin R, et al. Part 1: executive summary: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with treatment recommendations. *Resusc.* 2015;95:e1–31.
2. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: the "Chain of Survival" concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. *Circ.* 1991;83(5):1832–1847.
3. Travers AH, Perkins GD, Berg RA, et al. Part 3: adult basic life support and automated external defibrillation: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with treatment recommendations. *Circ.* 2015;132(16 Suppl 1): S51–S83.
4. Beck B, Bray J, Cameron P, et al. Regional variation in the characteristics, incidence and outcomes of out-of-hospital cardiac arrest in Australia and New Zealand: results from the Aus-ROC Epistry. *Resusc*. 2018;126: 49–57.
5. Wang PL, Brooks SC. Mechanical versus manual chest compressions for cardiac arrest. Cochrane Database Syst Rev. 2018;8:Cd007260.
6. Flato UA, Paiva EF, Carballo MT, et al. Echocardiography for prognostication during the resuscitation of intensive care unit patients with non-shockable rhythm cardiac arrest. *Resusc.* 2015;92:1–6.
7. Hagihara A, Hasegawa M, Abe T, et al. Prehospital epinephrine use and survival among patients with out-of-hospital cardiac arrest. *JAMA.* 2012;307(11):1161–1168.
8. Perkins GD, Ji C, Deakin CD, Quinn T, Nolan JP, Scomparin C, et al. A Randomized Trial of Epinephrine in Out-of-Hospital Cardiac Arrest. 2018;379(8):711–721.
9. Chowdhury A, Fernandes B, Melhuish TM, White LD. Antiarrhythmics in Cardiac Arrest: A Systematic Review and Meta-Analysis. Heart Lung Circ. 2018;27(3):280–290.
10. Khan SU, Winnicka L, Saleem MA, Rahman H, Rehman N. Amiodarone, lidocaine, magnesium or placebo in shock refractory ventricular arrhythmia: A Bayesian network meta-analysis. Heart Lung. 2017;46(6):417–424.
11. Sasson C, Hegg AJ, Macy M, et al. Prehospital termination of resuscitation in cases of refractory out-of-hospital cardiac arrest. *JAMA*. 2008;300(12):1432–1438.