



Defining a standard medication kit for prehospital and retrieval physicians: a comprehensive review

J Sadewasser,¹ A Potter,² D Ellis³

¹CareFlight Medical Services, Queensland, Australia; ²Cairns Base Hospital, Department of Anaesthetics, Cairns, Queensland, Australia; ³University College London Hospital, London, Essex and Herts Air Ambulance and Helicopter Emergency Medical Service, London, UK

Correspondence to:
Dr J Sadewasser, CareFlight Medical Services, EMQ Hangar 12, Bushpilot Avenue, Aeroglen, Queensland 4870, Australia; sadewasser@lycos.com

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ABSTRACT

Background: There is little consolidated evidence for which prehospital and retrieval drugs a given service should carry.

Objectives: To suggest a core group of drugs based on the best evidence currently available.

Methods: This paper has reviewed documents from recognised evidence-based sources and put together an initial skeleton for an evidence-based drug pack.

Results: The resultant list of drugs is divided up into core agents with suggestions for regional variations. This may be of particular interest to de novo services.

Conclusions: This review offers a starting point for services based on the evidence currently available. It is hoped that prehospital and retrieval clinicians will start to look analytically at what they carry and, through a process of audit, aim to improve the evidence in this area. Future reviews and comparisons of worldwide prehospital and retrieval databases are suggested.

A number of general approaches to prehospital emergency medicine are found across the world. These range from an almost exclusively paramedical service found in the USA and the UK to the physician-led services seen in other western European countries. In recent years the role of the prehospital physician has evolved, and increasing numbers of services use doctors in this field.¹⁻⁸

Traditional systems such as the Royal Flying Doctor Service in Australia and newer international retrieval services and aid organisations (eg, International SOS, Malteser International) also use doctors when working in isolated areas to rescue and treat patients who otherwise have little access to medical care.⁹⁻¹² In North America, signs of increasing involvement of physicians in certain out-of-hospital scenarios can also be found.^{4 13} Air medical and other remote area emergency services treat a large number of patients with a broad spectrum of diseases and injuries. All these services differ in what they provide based on several factors such as location, target population, limitations due to budget and the standards of the health system in which they work.

Despite the variety of environments and retrieval systems across the world, it should be possible to define a reasonable standard of what medications the physician should find in the medical kit. This should be based on up-to-date evidence and treatment recommendations. There is currently little consolidated evidence for which drugs a given prehospital and retrieval service should carry. We will describe a core medication list for use in the aeromedical setting and also mention extra medications relevant to services in particular regions.

Few articles present evidence or have given peer-reviewed guidelines for intra- and interhospital transfer equipment.¹⁴ None were found that related specifically to prehospital services.

The objective of this study is to define medications to be carried on physician-staffed general prehospital and retrieval services and other remote area emergency services based on current evidence. Sub-specialised retrieval services (eg, neonatal) are not considered in depth.

METHODS

Using recommendations of evidence-based medical research guidelines,¹⁵⁻¹⁷ databases were identified that offer access to up-to-date validated and peer-reviewed information. Most of these databases are filtered and pre-appraised.

A review of current guidelines and evidence was independently performed by two of the authors using the sources and search terms shown in tables 1 and 2.

The general terms in table 1 were combined with a list of injuries and differential diagnoses as described in table 2. This table represents the spectrum of disease and injury as well as major complications and differentials established by reviewing the database of CareFlight Medical Services, Townsville, Queensland, Australia. This service offers the full range of prehospital and retrieval cases and is tasked directly by a consultant emergency physician. Cases range from medical and trauma primary missions to critical care and low-dependency interfacility transfers.

Retrieval physicians at this base work onboard a Bell 412 rotary wing aircraft operated by Emergency Management Queensland (EMQ)¹⁸ and also on a fixed wing Beechcraft Super King Air B200 aircraft operated by the Royal Flying Doctor Service of Australia (Queensland Section).⁹

Although this list is representative for the tropical environment of North Queensland, Australia, we feel that this CareFlight service offers a reasonably standard cross-section of prehospital and retrieval work. The general case mix is likely to be similar for services operating in temperate as well as tropical zones in both the Northern and Southern hemispheres. Pathologies specific to location (eg, envenomations) have been described separately. There is no attempt to describe the frequency of each condition as this is beyond the scope of this review. Certain environmental conditions (eg, hyperthermia) were complemented by their natural counterpart (eg, hypothermia), even if these were not encountered in our service.

The final list of pathologies was tested against data taken from the United Nations (UN)

Table 1 Search sources and general terms

Searched sources	Web link	Search terms for all sources
BMJ Clinical Evidence	http://clinicalevidence.bmj.com	management
Cochrane Library for Systematic Reviews	http://www.mrw.interscience.wiley.com/cochrane*	OR treatment
National Guideline Clearinghouse	www.guideline.gov*	OR guideline AND/OR acute
POISINDEX by Thomson	http://www.thomsonhc.com*	OR urgent
Micromedex GV		OR emergency
eMedicine from WebMD	www.emedicine.com	AND/OR field
		OR prehospital
		OR air-medical
		OR air-ambulance
		AND/OR medication\$ OR drug\$ OR agent\$ AND/OR adult
		OR neonatal
		OR paediatric

*Searched using Unified Search Environment by Health Communication Network Limited (<http://www.use.hcn.com.au>).

Emergency Service provided in Aceh Province, Indonesia by Malteser International between September 2005 and September 2006. The purpose of cross-checking with a second service was to ensure that core pathologies were indeed similar. The comparison in this case led to the inclusion of malaria, but no other relevant medical search terms were identified as missing.

Using a service's genuine database has allowed search terms to be based on diagnoses and injuries actually found in a prehospital and retrieval service and not on the authors' personal choices. We have not attempted to define the "core list" of pathologies relevant to the prehospital and retrieval environment worldwide. Rather, we acknowledge that no single

service (or even several services) can be representative for all such services. However, we are confident that this strategy has ensured an adequate broad-based framework for the search.

Data of patients treated between 1 August 2006 and 31 July 2007 were analysed to extract the CareFlight search terms. Patient data were collected between 28 September 2005 and 6 February 2006 from the UN Emergency Service in Aceh provided by Malteser International.

The above described search method had to be modified for parts of the airway and breathing section of the review—specifically, rapid sequence induction and maintenance of anaesthesia in the out-of-hospital setting. Despite the

Table 2 Medication categories and diagnosis-related search terms

Category*	Terms (†included but not encountered in CareFlight cohort)
Airway/breathing	Induction, intubation, rapid sequence, ongoing sedation, anaesthesia, narkose, rettungsdienst, asthma, severe, status asthmaticus, anaphylaxis, allergy, airway burn, inhalation trauma, COAD, COPD, chronic obstructive airway disease, exacerbation, croup, respiratory distress, bronchiolitis, foreign body, airway
Circulation/cardiovascular	Hypovolaemia, dehydration, shock, haemorrhagic, hypovolaemic, fluid resuscitation, distributive, cardiac arrest, PEA, asystole, ventricular fibrillation, -tachycardia, tachyarrhythmia, bradyarrhythmia, complete heart block, supraventricular, SVT, AF, PSVT, WPW, hyperkalaemic, torsades de pointes, cardiac failure, cardiogenic shock, acute pulmonary oedema, APO, acute coronary syndrome, ACS, myocardial infarct, NSTEMI, STEMI, unstable angina, pulmonary embolism, PE, aortic aneurysm, ruptured, leaking, dissection, thoracic, abdominal, heat, -exhaustion, -stroke, syncope
Trauma	Analgesia, conscious, pain management, sedation, burns, spinal injury, fracture, dislocation, reduction, head injury, - penetrating, traumatic brain injury
Psychiatric	Psychosis, schizophrenia, sedation, aggression
Poisoning/overdose	Poisoning, overdose, tricyclic antidepressants, TCA, benzodiazepines, opioids, carbamazepine, paracetamol (acetaminophen), alcohol, polypharmacy, organophosphates†, diphenhydramine†, digitalis†
Envenomation	Snake bite, envenomation, irukandji syndrome, marine stinger, jellyfish, stonefish, fish
Neurological/neurosurgical	Seizure, recurrent, status epilepticus, altered level of consciousness, delirium, stroke, cerebrovascular accident, CVA, subarachnoid, intracranial, subdural, -haemorrhage, -bleed, SAH, SDH, ICH
Surgical	Acute abdomen, gastrointestinal bleed, epistaxis, eye injury, -penetrating
Obstetric	Postpartum bleed, complicated labour, labor, third stage, shock, pregnancy, preterm, premature, rupture membranes, newborn, prematurity, eclampsia, preeclampsia
Infection	Sepsis, no source, unknown source, septic shock, respiratory, abdominal, genito-urinary, soft tissue, necrotizing fasciitis, meningitis, brain, epidural, abscess, malaria†
Metabolic	Diabetic ketoacidosis, DKA, diabetic emergency, hypoglycaemia, hyperkalaemia, hyponatraemia, hypokalaemia†, hypocalcaemia†
General	Vomiting, travel-, motion sickness, anxiety, agitation, drowning, near drowning, hypothermia†, decompression illness, -sickness, altitude illness†

*Respiratory, paediatric/neonatal, anaphylaxis/allergy merged into several categories.

†Not CareFlight Medical Services.

Prehospital care

importance of this area, the chosen databases contained no evidence-based or peer-reviewed results so the world wide web, Medline and PubMed were searched for any other current information.

Not all search results were included for data extraction. If guidelines provided identical advice, the most recent was included. If information was available from higher grade sources, then the lower grade reference (eg, *eMedicine*) was not included unless it contained additional information.

Where evidence did not support specific drugs within a substance group, no author preference was applied. In this way the article attempted to eliminate personal preference and to deliver objective criteria for the choice of drug. However, it does reflect current opinion and evidence and, as such, it will date with the emergence of new evidence in the future.

The specific dosages and quantities of recommended drugs are beyond the scope of this article. It is also appropriate for organisations to carry a locally recognised drug dose book for adult and paediatric patients (eg, *British National Formulary* in the UK).

For the purpose of this article it is assumed that the available technical equipment enables the physician to use all the drugs described (eg, 12-lead ECG, ventilator, pacing facilities, defibrillator, syringe pump).

RESULTS

Figures 1 and 2 illustrate the range of clinical services provided over a 12-month period by the Townsville CareFlight Medical Service base.

Primary responses were predominantly tasked for trauma (47%), followed by cardiovascular emergencies (17.9%), of which half were acute coronary syndrome (ACS). Other common primary taskings were surgical emergencies (9.4%) and poisonings/envenomations (8.5%). Almost one-third of all interfacility transfers were performed for patients with cardiovascular problems (31.9%, ACS 24.9%), with trauma ranked second (23.5%).

A representation of the case mix in the UN Emergency Service in Aceh Province, Indonesia is shown in fig 3.

The search identified 241 potential reference sources (22 from *BMJ Clinical Evidence*, 49 from National Guidelines

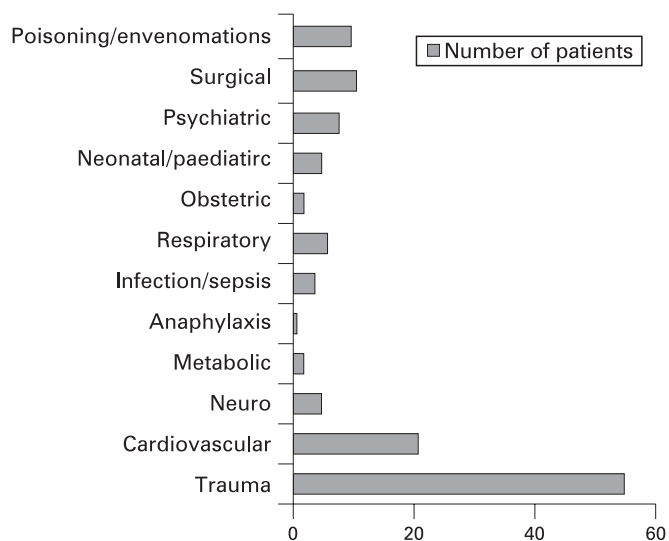


Figure 1 Primary responses by CareFlight Medical Service over a 12-month period.

Clearinghouse, 52 Cochrane reviews, 3 from Micromedex, 113 from *eMedicine* from WebMD and 4 others); 144 were included for data extraction after initial review.

Medical search terms extracted from CareFlight case data were grouped into clinical categories (table 2).

All extracted drug recommendations are shown in table 3, in accordance with the clinical categories defined in table 2. For brevity, some drugs are not discussed at length in the paper but the references have been included in the table for completeness.

The recommendations for a standard drug kit are shown in table 4. Recognising the distinct differences in each prehospital and retrieval service, certain medication groups have been included in a separate column. These medications cannot be considered "core" but will vary, particularly with geographical location.

DISCUSSION

When considering the range of medications carried, it must be acknowledged that some services will have targeted tasking (eg, London HEMS, exclusively trauma) whereas others serve as a general prehospital emergency service. The following recommendations are predominantly aimed at services that attend a varied case mix of patients.

The drugs are discussed under headings for convenience, but there is considerable overlap for different agents (eg, opioids).

Airway management

Etomidate (unlicensed in Australia) is one of the most frequently recommended induction agents because of its favourable haemodynamic profile. Despite the current controversy regarding the side effect of adrenal suppression, the advantages are thought to outweigh the potential risk, particularly as adding a corticosteroid may compensate to some degree.¹⁹⁻²⁵

Ketamine has advantages in asthma and is also used for short-term sedation and analgesia because of its favourable effect on airway reflexes and its positive haemodynamic profile.^{19 20 25-27}

Thiopentone has been described as neuroprotective and has additional antiepileptic properties.^{20 28}

Prehospital intubation guidelines found in this search did not include propofol in their recommendations.^{19 21-23} This might be explained by its negative haemodynamic and respiratory effects;²⁵ preference is given to etomidate. Its role in sedation is supported in the literature, especially when a short duration of action is preferred,^{25 30} and also as an alternative anticonvulsive agent.²⁸ There is also a warning of lactic acidosis, especially in children, following prolonged use of propofol infusions which restricts its use in paediatric practice.²⁵

Fentanyl is preferred as an induction and sedation agent for neonatal patients.^{21 29} It has a faster onset of analgesic action and superior haemodynamic stability compared with morphine.³⁰

All current guidelines recommend suxamethonium as the primary muscle relaxant for intubation.¹⁹⁻²³ However, in a few clinical situations it is contraindicated. For this reason, rocuronium should be included. It has a sufficiently quick onset of action to be used for rapid sequence induction, yet its duration of action is long enough to be useful for maintenance non-depolarising muscle relaxation.^{19 21}

Other non-depolarising muscle relaxants lack a significant advantage or evidence in their favour.

The reviewed guidelines suggest either midazolam or lorazepam as the primary benzodiazepine, the latter supported by

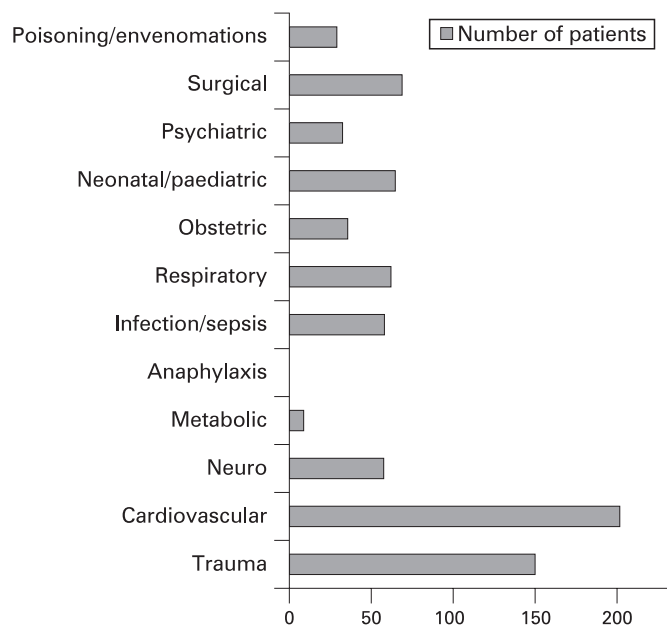


Figure 2 Interfacility transfers provided by CareFlight Medical Service over a 12-month period.

some evidence as being superior to diazepam in controlling seizure activity.^{31 32}

Midazolam is more widely recommended and available for intravenous use for airway management.^{19 21 22} It is also suggested for sedating agitated^{25 30} or psychiatric patients³³ and in the management of status epilepticus.^{28 34–36}

It could be argued that the lack of active metabolites makes lorazepam a more ideal agent, but the option of intramuscular administration (and no need for refrigeration) gives midazolam a certain advantage in the prehospital setting.³⁴

Obstructive airway disease and steroids

Asthma management guidelines are well established and recommend a short-acting β_2 agonist as the first-line agent, usually salbutamol (albuterol)^{26 27 37–39} or, less commonly, terbutaline. In the out-of-hospital setting, intravenous preparations can be important and their effectiveness has an evidence base.⁴⁰ In patients who are close to respiratory arrest, especially in the environmental extremes of the prehospital setting, intravenous drugs may be more reliable.

Beta₂ agonists are also recommended in the treatment of hyperkalaemia^{41 42} and for tocolysis,^{43 44} although there is some evidence to question their effectiveness for the latter.⁴⁵

Ipratropium bromide is recommended as the anticholinergic drug of choice in asthma and chronic obstructive airway disease.^{26 27 37–39 47–49}

Although there is some evidence to suggest a possible advantage from intravenous theophylline in the management of children with asthma (albeit with a significantly increased adverse effect of vomiting),³⁹ other sources currently strongly discourage the use of theophylline and aminophylline.³⁷

Current evidence firmly supports the early use of corticosteroids in asthma,^{26 27 37–39 50 51} anaphylaxis,^{52 53} chronic obstructive airway disease,^{47 54} croup,^{55–57} threatened premature labour including pre-eclampsia/eclampsia,^{43 45 58} fluid-resistant septic shock^{29 59–62} and altitude illness.⁶³ Specifically, dexamethasone and methylprednisolone are directly supported by evidence in some of these clinical circumstances. Dexamethasone seems to

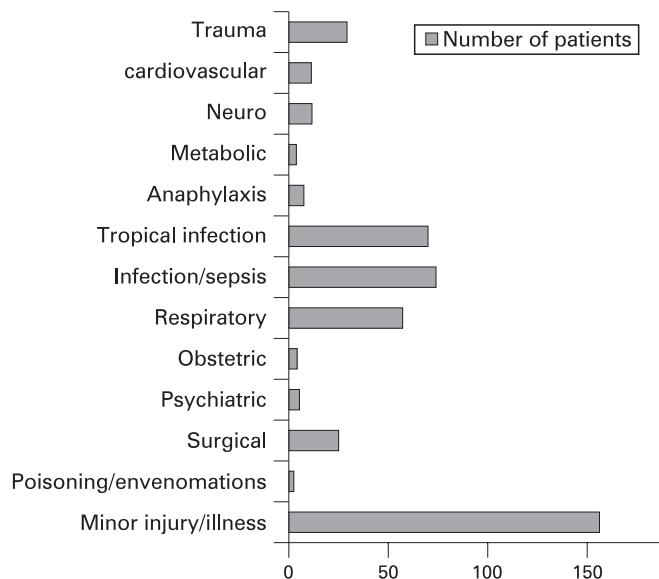


Figure 3 Case mix in the United Nations Emergency Service provided in Aceh Province, Indonesia.

be supported in the more acute situations.^{37 45 55 61 62} Despite some evidence for the use of methylprednisolone early in spinal cord injury,^{64 65} its use remains controversial. Among other things, it may do significant harm in patients with coexisting head injury.⁶⁶

Circulation

Intravenous fluids are required for the management of trauma but also in many other clinical settings (eg, anaphylaxis, shock, dehydration, diabetic ketoacidosis). Current evidence does not show an advantage for either crystalloids or colloids,^{67–70} nor any specific substance in either group.⁷¹ Normal saline (NaCl 0.9%) is commonly considered as an appropriate choice for all situations and ages.^{29 52 67 69 72 73} The issue of sodium loading and hyperchloraemic metabolic acidosis⁶⁹ should be acknowledged. Disadvantages of lactated Ringer's solution during the acute resuscitation phase have been suggested.^{52 72}

Acute haemorrhage is best corrected with blood itself or red packed cells.⁷⁴ Although a physiological necessity in certain situations, no direct evidence was found that supports this recommendation. Some services have shown that the technical problems of maintaining the “cold chain” for blood products are not insurmountable. O negative red packed cell units are the obvious choice, being recognised as the universal donor blood group.

Another fluid for consideration is hypertonic (3%) saline, for which there is some evidence to suggest better efficacy than mannitol in treating increased intracranial pressure in head injury.^{75 76} Hypertonic saline also lacks the potential dangers of mannitol in hypovolaemia. Its use has also been suggested in the treatment of burns,⁶⁹ and it might be safer in symptomatic hyponatraemia and poisoning with tricyclic antidepressants than sodium bicarbonate.^{77 78}

The primary vasoactive substance in all current guidelines on advanced life support is epinephrine (adrenaline).^{67 68 79–83} It is also a primary choice or an option in the treatment of anaphylaxis, croup and different forms of shock.^{53 55 57 83}

Reviews on vasopressors in shock in general were unable to recommend a single substance.⁸⁴

Table 3 Search result: drugs by clinical problem category

	Drugs identified in guidelines, recommendations
Airway, breathing	Suxamethonium, rocuronium, vecuronium, atracurium, pancuronium, thiopentone/thiopental, etomidate, ketamine, midazolam, short-acting β_2 agonists iv, neb, sc (salbutamol/albuterol,terbutaline), corticosteroids iv, po, neb (methylprednisolone, prednisone, hydrocortisone, dexamethasone, budesonide), magnesiumsulfate, methylxanthines (aminophylline), anticholinergics (ipratropium), lidocaine, fentanyl, atropine, epinephrine/adrenaline IV, SC, IM, H ₁ -antihistamines (diphenhydramine), H ₂ -antihistamines (ranitidine) ^{15-27 37 38 40 46-50 52-57 143-145}
Circulation, cardiovascular	Colloids, crystalloids (NaCl 0.9%, lactated Ringer's) dopamine, dobutamine, norepinephrine/noradrenaline, epinephrine, vasopressin, corticosteroids (dexamethasone, hydrocortisone), adenosine, amiodarone, procainamide, magnesium, sodium bicarbonate, atropine, calcium (chloride, gluconate), beta-blocker (metoprolol, labetalol, esmolol, propranolol), calcium channel blockers (verapamil, nifedipine), aminophylline, isoprenaline, digoxin IV, lidocaine, flecainide, ajmalin, glucose, naloxone, sotalol, vasopressin, potassium, analgesia (morphine), heparin, LMWH (enoxaparin), nitrites (GTN) SL, IV, SNP, loop diuretics (furosemide), fibrinolytics (reteplase, alteplase, tenecteplase), aspirin, clopidogrel, ACE inhibitors, glucagon ^{52 53 67 68 71 79-103 146-149}
Trauma	Normal saline, lactated Ringer's solution/Ringer lactate, hypertonic saline (3%), opioid analgesia (fentanyl, morphine), benzodiazepines (midazolam, diazepam, lorazepam), propofol, etomidate, thiopentone, methohexital, ketamine, methylprednisolone, mannitol, vasopressors, phenytoin, nimodipine, blood/red packed cells/O neg ^{30 64-66 69 75 76}
Psychiatric	Lorazepam, midazolam, droperidol, haloperidol, cogentin, ziprasidone ^{25 30 33 105 106 150}
Poisoning	Atropine, glycopyrolate, charcoal, calcium, glucagon, epinephrine, sodium bicarbonate, N-acetylcysteine, hypertonic saline (3%), vasopressors, naloxone, thiamine, glucose, benzodiazepines, GTN, SNP, haloperidol, diuretics, magnesium, insulin, inotropes, potassium, phenytoin, lidocaine ^{78 108 124-134 139}
Envenomation	Snake antivenom, epinephrine, corticosteroids, antihistamines (H ₁ and H ₂), opioid analgesia (morphine, fentanyl, meperidine), antiepileptics, crystalloid, colloid, inotropes, vasopressors, GTN, phentolamine, magnesium, box-jellyfish-antivenom, vinegar, bupivacaine ^{135-138 151}
Neurological, neurosurgical	Glucose, thiamine, lorazepam, diazepam, midazolam, propofol, barbiturates (thiopental), phenytoin/fosphenytoin, pyridoxine, antibiotics, phenobarbital, calcium, magnesium, haloperidol, physostigmine, aspirin, mannitol, hypertonic saline (3%), labetalol, esmolol, nitroglycerin, narcadipine, enalapril, hydralazine, nipride, etomidate, lidocaine, furosemide, fentanyl, nimodipine ^{20 28 31 32 34-36 64-66 75 76 150 152-154}
Surgical	Proton pump inhibitors, crystalloid, blood, antiemetics, analgesia, antibiotics (cephalosporin, gentamicin, fluoroquinolones) ^{74 155 156}
Obstetric	Steroids (betamethasone, dexamethasone), magnesium, terbutaline/salbutamol, indomethacin, nifedipine, oxytocin, ergot alkaloids (ergotamine), misoprostol, prostaglandin, labetalol, nifedipine, hydralazine, calcium, diazepam, thiopentone ^{35 43-45 58 85 110-113 157}
Infection, sepsis	Crytalloids (normal saline), colloids, vasopressors (dopamine, norepinephrine), epinephrine, inotropics (dobutamine), hydrocortisone, β -lactam antibiotics (penicillin, third-generation cephalosporin, carbapenem), aminoglycosides (gentamicin), meropenem, metronidazole, ampicillin, cefotaxime, ceftriaxone, vancomycin, piperacillin+tazobactam, dexamethasone, hydrocortisone, prednisolone, aciclovir, ceftazidime, paracetamol, artesunate, mefloquine ^{29 36 59-62 70 85 86 115-118 120-123 152 158}
Metabolic	Normal saline, Ringer's lactate, potassium, insulin (Actrapid), sodium bicarbonate, glucagon, glucose, salbutamol, calcium, magnesium, furosemide, hypertonic saline (3%) ^{41 42 73 77 107 109 159 160}
General	Phenothiazines, butyrphenones, metoclopramide, H ₁ -antihistamines, muscarinic/M ₁ -antagonists, serotonic 5HT ₃ -antagonists (ondansetron), scopolamine (hyoscine), crystalloid, colloid, dopamine, doputamines, sodium bicarbonate, aspirin, dexamethasone, furosemide, mannitol, acetazolamide ^{25 63 72 104 140-142 161 162}

GTN, glycerol trinitrate; IM, intramuscular; IV, intravenous; LMWH, low molecular weight heparin; NEB, nebuliser; PO, oral; SL, sublingual; SNP, sodium nitroprusside.

Norepinephrine (noradrenaline) is suggested as the primary vasoactive substance for shock in pregnancy.⁸⁵

For shock in newborn infants, dopamine is suggested as the primary choice.⁸⁶ Dobutamine is recommended to treat low output situations (eg, cardiogenic shock, sepsis) due to its positive inotropic action.^{70 83}

There was no evidence to suggest a survival benefit by choosing a specific substance.

In services which operate over long distances and provided they have appropriate intravascular access and monitoring, it may be sensible to carry several vasoactive and inotropic substances to cater for the individual patient.

Cardiovascular

Even though there is little evidence from prospective high quality research into antiarrhythmic drugs in resuscitation, there is currently a good consensus on the primary treatment of arrhythmias.^{67 68 79 81 82 87-91} Based on this consensus, the following drugs should be included: amiodarone, adenosine, atropine, calcium chloride, sodium bicarbonate, magnesium sulfate.

The guidelines on treatment of acute coronary syndrome (ACS), including prehospital management, are some of the best defined. Aspirin (acetylsalicylic acid), clopidogrel, nitroglycerin, opioid analgesia, heparin, β blockers and fibrinolytic drugs are "standard of care" in their indicated clinical setting.⁹²⁻⁹⁶

Morphine seems to be the recommended opioid in ACS,^{94 95} although little evidence was found to support its use. In addition, the longer duration of analgesic action makes morphine a reasonable choice on services that cover longer distances.

Low molecular weight heparins (LMWH) as well as unfractionated heparins are recommended in the treatment of ACS and pulmonary embolism.⁹⁶⁻⁹⁹ The ease of administration without the need for continuous infusion or monitoring of the coagulation profile should lead to a preference for LMWH.

Metoprolol is available as an intravenous preparation and is considered as an option for the treatment of ACS (with and without cardiac failure),⁸³ aortic dissection¹⁰⁰⁻¹⁰² and tachyarrhythmias.^{67 68 89 91}

Intravenous calcium antagonists may be an alternative to β blockers but are contraindicated in some settings (eg, ACS, Wolf-Parkinson-White).^{83 89 92}

Table 4 Drug pack content according to service type

Urban/short range	Remote/long range	Special substances (not "core")
Etomidate, ketamine, thiopentone	Adenosine	Norepinephrine
Fentanyl	Clopidogrel	Dobutamine
Suxamethonium, rocuronium	Morphine	Thiamine (IV)
Midazolam	O negative blood (red packed cells)	Actrapid
Normal saline (0.9%)	Hypertonic saline (3%)	Potassium chloride (IV)
Epinephrine	Nitroglycerin (IV)	Acetazolamide (IV)
Amiodarone, calcium chloride, magnesium sulfate, sodium bicarbonate, lidocaine	Dexamethasone (IV/IM) Ipratropium bromide (NEB)	Antibiotics*†
Salbutamol/albuterol or terbutaline (IV, NEB)	Glucagon, vasopressin	Antimalarials*
Aspirin (PO/IV)	Beta blockers* (eg, metoprolol IV)	Antivenin†
Nitroglycerin (SL)	Nifedipine (PO)	Antidotes†
Low molecular weight heparin* (eg, enoxaparin)	Haloperidol, benzotropine	
Loop diuretics* (eg, furosemide)	Phenytoin/fosphenytoin	
Glucose (IV)	Ergot alkaloids* (eg, ergotamine)	
Naloxone	Bupivacaine	
Oxytocin	Scopolamine/hyoscine	
H ₁ -antihistamines*, ondansetron	Fibrinolytics*‡	
Antibiotic for meningitis†		

IM, intramuscular; IV, intravenous; NEB, nebuliser; PO, oral; SL, sublingual.

*No clear preference within group of drugs.

†As locally indicated/recommended.

‡Percutaneous coronary intervention not available.

There is evidence to support the use of nitroglycerin, not just in ACS.^{92–95} It should be available as a sublingual as well as an intravenous preparation. Its intravenous formulation is supported in the treatment of cardiac failure,^{83 103} and also for other hypertensive emergencies such as aortic dissection.¹⁰⁰ The general familiarity with its administration as well as its safety profile make it a first-line choice compared with sodium nitroprusside which is recommended only with invasive monitoring.^{83 103}

Prehospital thrombolysis in acute ST elevation myocardial infarction is indicated in the first 3 h after onset of symptoms, especially if the transfer to hospital is longer than 30 min. It is also indicated between 3 and 12 h if percutaneous coronary intervention cannot be performed within 90 min.^{94 96} Thrombolysis is also an option in pulmonary embolism, especially if the patient deteriorates into cardiac arrest.^{97–99}

Tenecteplase and reteplase are the fibrinolytic drugs of choice.⁹⁴

Loop diuretics (eg, furosemide) are strongly recommended in cardiac failure with pulmonary oedema^{83 105} and have a place in the management of hyperkalaemia.⁴²

Acetazolamide has an important role in the treatment of altitude sickness and should be considered in services working in this environment.^{63 104}

Psychiatry

Guidelines for the treatment of delirium and acute psychosis recommend haloperidol.^{30 33 105 106} The evidence supports a combination with benzodiazepines as this may reduce side effects.¹⁰⁵ Benzotropine should be available to prevent or treat side effects.¹⁰⁶

Neurology

Status epilepticus is a frequent and potentially life-threatening prehospital problem and will have to be managed medically at the scene and during transport. Midazolam and thiopentone are part of the recommended treatment guidelines^{28 34} and have

already been discussed. Phenytoin (or fosphenytoin) is strongly recommended in seizures not responding to a benzodiazepine,^{28 34} including pregnant and neonatal patients.^{35 36} The use of magnesium in eclamptic seizures is discussed below.

Metabolic/endocrine

Hypoglycaemia is best treated with intravenous glucose.¹⁰⁷ Glucagon is a second-line treatment if intravascular or intraosseous access is unavailable.¹⁰⁷ Its potential use should also be considered for calcium antagonist poisoning,¹⁰⁸ and it has been suggested for the treatment of unresponsive hypotension in anaphylaxis for patients on β blockers.⁵⁵

Diabetic ketoacidosis is a common and potentially fatal emergency. The primary treatment consists of fluid replacement (eg, NaCl 0.9%) and initiation of a short-acting insulin (eg, Actrapid) infusion while considering potassium levels.^{73 107 109}

Services that provide patient care over long distances or in remote locations will be required to initiate insulin treatment. In this scenario, potassium (potassium chloride) will likely have to be replaced also. Without access to serum potassium levels, it is prudent to wait until the patient passes urine before giving potassium.^{73 109} Cooling requirements for insulin are not a unique problem and can be solved in the same way as carriage of blood products.

In any patient with an altered level of consciousness, glucose and thiamine may be required as part of good practice guidelines.²⁸

Obstetric

Obstetric emergencies in remote areas are not uncommon as access to antenatal care may be limited. Tocolysis and steroids have already been mentioned for threatened premature birth. Nifedipine as an oral calcium channel antagonist is currently thought to be considered the best tocolytic drug^{43–45} and should be carried for that purpose. The management of birth and obstetric complications also includes oxytocin and ergot

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alkaloids (eg, ergotamine). Strong recommendations exist and there is good evidence to support these two drugs.^{43 85 110–112}

Eclampsia and severe pre-eclampsia require magnesium sulfate.^{58 113 114}

Infection

A patient with sepsis or in septic shock will require fluids, vasoactive substances and steroids, as previously mentioned.^{29 59 60 70}

Early antimicrobial agents will be required, not only in sepsis but also in meningitis and malaria.^{59 61 115 116} There is no perfect single or combination treatment for bacterial sepsis.^{117 118} Availability, costs and local bacterial resistance patterns will have a great impact on the choice of agents. A review of all guidelines and evidence suggests a combination of ampicillin, a broad-spectrum cephalosporin (eg, cefotaxime, ceftriaxone) and vancomycin.^{61 115 119–121}

Ceftazidime would offer good cover for neutropenic sepsis by itself.¹¹⁵ Meropenem is an alternative as it has a similar spectrum to aminoglycosides, acts very well against *Pseudomonas* and anaerobic bacteria and penetrates the blood-brain barrier easily.⁶¹

Some good quality evidence for the treatment of severe malaria supports intravenous artesunate in combination with mefloquine as being superior to older regimes.^{116 122 123}

Aciclovir should be considered as the preferred treatment for herpes encephalitis on long distance services, especially for neonatal patients.³⁶

It would be appropriate for individual retrieval services to liaise with the local microbiology service to select appropriate antimicrobial agents for the spectrum of infectious diseases likely to be seen in their region. The choice of antimicrobial agent should therefore be considered separately from the core drug selection.

Toxicology and toxinology

Poisonings and envenomations were fairly common in the CareFlight patient cohort. It is not possible to prepare for all possible drug ingestions, but the most common and treatable should be considered. As such, these drugs cannot be considered “core”, but their inclusion will be decided at the local level. Several drugs already mentioned can also be used for this group of patients.

Atropine is an essential agent for the treatment of organophosphate poisoning.¹²⁴ Calcium, glucagon and epinephrine may be required after calcium antagonist ingestion.¹⁰⁸ Sodium bicarbonate or hypertonic saline and antiepileptic drugs are part of the pharmacological treatment of poisoning from tricyclic antidepressants.^{78 125}

Salicylate poisoning may require treatment with sodium bicarbonate, hydration and correction of hypoglycaemia.¹²⁶

Amphetamine poisoning will likely require benzodiazepines, haloperidol for psychosis as well as nitroglycerin and loop diuretics for hypertension and pulmonary oedema.¹²⁷

Beta blocker overdose can be problematic as the common vasoactive and inotropic substances may not work on the blocked receptors. Glucagon and insulin/dextrose are suggested as treatment.¹²⁸ An alternative agent is vasopressin, and some guidelines also suggest vasopressin as an alternative treatment approach in cardiac arrest^{79 82} and refractory septic shock.⁵⁹

N-Acetylcysteine is a drug that should also be included in the medication kit. It is proven to work¹²⁹ and is almost 100%

hepatoprotective if started within 8 h of paracetamol (acetaminophen) overdose.¹³⁰

Poisoning from benzodiazepines, carbamazepine, ethanol and narcotics will be best managed by protecting the airway as well as by cardiovascular support and treatment of hypoglycaemia.^{131–134} Opioids can be reversed with intravascular or intramuscular naloxone, although this may generate other problems, especially in the prehospital setting.¹³⁴ If the opioid action is reversed completely and too rapidly, a number of patients could become uncooperative or even violent. There is the possibility of acute opioid withdrawal but, more significantly, issues with patients who initially refuse further medical help and go on to develop difficulties due to the short action of naloxone.

Venomous plants and animals are uncommon or non-existent in some areas but are a major problem in others. Any service retrieving patients over long distances in areas with lethally toxic flora and fauna should consider adequate specific treatment and antivenin.

Snake antivenin can quickly reverse coagulopathy and neurotoxicity that might otherwise require ventilation or cause significant problems. Rhabdomyolysis may be avoided leading to a reduction in associated morbidity and mortality.^{135 136}

In some Coelenterate envenomations (box jellyfish, *Chironex fleckeri*), resuscitation efforts can be futile unless antivenom is urgently administered (within 5–20 min), even if the hospital is relatively close.¹³⁷

As described for antimicrobial agents, antivenins will not be required by all services so are not considered as core drugs but may be indicated for local retrieval services.

Local anaesthetic drugs can be very useful in easing pain after contact with marine animals such as stonefish,¹³⁸ but also have a role in general trauma. Bupivacaine has a long duration of action and combination with lidocaine can hasten the onset of analgesia. Local anaesthetics can also facilitate procedures in prehospital trauma care (eg, tube thoracostomy). Lidocaine is also useful as a second-line antiarrhythmic drug.^{87 139}

Simple issues like nausea, not usually considered a threat to life, can become a major problem for prehospital and retrieval services. H₁-antihistamines such as cyclizine are one option,¹⁴⁰ especially as they might also be helpful in allergy and anaphylaxis.^{52 53} Metoclopramide and ondansetron (especially for children) have shown general effectiveness.^{140 141} Scopolamine (hyoscine) has supporting evidence specifically for motion sickness.¹⁴²

In line with accepted clinical practice and resuscitation guidelines, provision of supplemental oxygen is a standard of care.^{38 42 50 56 67 68 94}

Anaphylaxis/allergy

Anaphylaxis and allergy have already been discussed in the footnote to table 2. Adrenaline, corticosteroids, crystalloids and/or colloids are core substances in the treatment of this condition and antihistamines also have a role.^{52 53}

A summarised list of all recommended drugs is shown in table 4.

CONCLUSION

Prehospital physicians should aim to deliver proven and, if possible, evidence-based treatment to achieve the maximum patient benefit.

Much of the equipment carried by prehospital and retrieval services is based on team experience and local need. However,

this review presents evidence to suggest that certain drugs could form the basis for an international consensus on prehospital and retrieval drugs. It is hoped that the application of such a review will encourage collaboration and research between organisations to improve the evidence base in this area. Further studies looking at data from several prehospital and retrieval services internationally are recommended.

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