This case-based book focuses on the principles of pre-hospital and retrieval medicine and the continuum of care provided for critically ill or injured patients in the field. Each question and discussion is usually illustrated with a photograph from author archives and real events. The cases are divided into those with a predominantly pre-hospital theme, those based around retrieval medicine, and a third section exploring service development and special circumstances. Essential reading for a broad range of emergency medical and non-medical personnel, the book features:

- visually assisted format and high level discussion
- operationally useful appendices, including recommended equipment lists
- coverage includes polytrauma, critical transfers, paediatric patients, major incidents and HAZMAT, flight physiology, advanced multi-organ support, crew resource management, and end of life discussions in the field
- designed for all members of a multidisciplinary team

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CASES IN
Pre-Hospital and Retrieval Medicine
For
Diana, Tomas and Emilia
Mel, Chloe and Bridget
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Pre-hospital care of the injured and ill is a complex and challenging field of medical endeavour. The breadth of clinical presentations encompasses all fields of trauma and acute internal medicine. Ideally, patients should receive the most advanced care possible at the earliest time, integrated with expedient transport to the most appropriate definitive care facility. The ability to deliver this is resource- and system-dependent with unique modifiers including aircraft and road transport logistics, environmental impacts and integration with other responding emergency services.

In this selection of clinical scenarios, Dan Ellis and Matthew Hooper have provided an extensive insight into the challenges that the pre-hospital and retrieval team faces in urban, regional and rural settings. They have drawn on their experience in civilian and military emergency medical services in UK, Australia and internationally, as well as their passion for teaching a generation of clinicians. Each case takes the reader through the mission with exposure to a wealth of clinical, logistic and problem-solving insights. Indeed, the great strength of this text is its artful blending of evidence-based clinical assessment and management with the operational skills and common sense essential for safe and effective participation in these most difficult environments. The question and discussion format lends itself to integration with a clinician training programme, with current literature references included for further study.

This text integrates knowledge of emergency medicine and critical care with a comprehensive exposure to pre-hospital and retrieval protocols and procedures derived from the authors’ many years of participation in fixed and rotary wing missions. As such, it is a unique and invaluable reference for all pre-hospital and retrieval clinicians and supporting personnel.

Allan MacKillop, FANZCA FFPMANZCA
Chief Medical Officer
CareFlight Group
Queensland, Australia
12 July 2009
Foreword 2

Experience gained at London HEMS and in aeromedical operations in Australia has given the authors unique exposure and experience in the delivery of pre-hospital and retrieval medicine. Their passion and commitment to this complex arena is obvious to those who have worked with them and distilled in this text for those who have not.

Much is written about the theory of pre-hospital medicine but little is based in real-life scenarios, such as those the authors have faced. This book gives the reader a genuine view of the dilemmas and solutions of every day pre-hospital and retrieval care for both the patient and the clinical team.

The style of the text reflects the authors’ depth of clinical understanding, their enthusiasm for human factors and the need for a team approach. The commentaries and discussions draw on their real-life experiences and are underwritten by well-chosen references.

The best performing units in the world deliver clinical excellence, not because they provide unique treatments or have access to highly technical equipment but because they deliver the most basic of care in a quality-assured manner with exquisite attention to detail. Such care is exactly what this book expounds.

It is with great pleasure that I commend this book to the pre-hospital and retrieval enthusiast from any background.

Gareth Davies, FRCP FFAEM
Consultant in Emergency Medicine & Pre-hospital Care
Medical Director, London HEMS
London, UK
16 July 2009
Cases in Pre-Hospital and Retrieval Medicine was conceived in 2005 and has evolved steadily over the ensuing four years into the current case-based format.

Having worked extensively in the pre-hospital and retrieval environments of Australasia and the United Kingdom and studied for many exams, including those for pre-hospital medicine, we felt that while several textbooks covered the relevant material, none had presented it in such a ‘user friendly’ case-based format. We felt this particular format would allow readers to become more immersed in the unpredictable and challenging pre-hospital and retrieval environments. In addition, we believed it would encourage the sort of lateral thinking required to provide safe, effective and high-level clinical care in such situations.

This book is not a replacement for any of the existing pre-hospital and retrieval texts; rather it is a complement to them. It provides an opportunity to consolidate the many disparate themes of this developing specialty and tie them together in a realistic, recognisable format that has a beginning, middle and end. The discussion presented for each case is not intended to provide a definitive review. Instead, reflection on personal experience and discussion with colleagues is recommended as there may be regional variation in several areas. When used in this way, we hope to have provided a valuable tool for teaching and learning that will appeal to a wide audience.

Both pre-hospital and retrieval medicine are sufficiently distinct from other critical care medical specialties to warrant consideration for independent specialty recognition. Whilst we believe that both fields of practice have enough in common to allow a single area of specialty to develop over time, we have maintained an arbitrary divide between the sections of the book to reflect that some clinicians are involved only in pre-hospital care and others only in medical retrieval. A third section for service development is aimed at highlighting the importance of crew resource management and the developing area of clinical coordination as well as covering medical tasks that are currently on the fringe of pre-hospital and retrieval medicine, but which we believe are integral to the specialty.

This is not a textbook for the latest management of emergency medical pathophysiology in itself, nor will it turn the reader into a trauma, intensive care, major incident or extrication specialist. Rather, we have used real emergency medical issues to highlight the role of the pre-hospital and retrieval specialist. This specialist must operate in a complex environment where approaching the scene, liaising with other emergency personnel and maintaining dynamic situational awareness can be at least as important as providing timely and high-level medical interventions.

All of the questions in Cases in Pre-Hospital and Retrieval Medicine are drawn from our collective experience over many years as pre-hospital and retrieval doctors and, thus, are based on real cases. We have also utilised the experience of acknowledged colleagues who have provided both images and commentary. On occasion, we have varied the images and the cases so as to augment key learning points and ensure patient confidentiality. However, we have attempted to always ensure that the reality of each case is reflected in the questions and discussions.
Our aspiration is for this text to become both a tool for education and a ready reference guide for clinicians, especially doctors, working in the out-of-hospital environment. By offering generic but relevant ‘real case’ discussion, we hope that the book will remain a useful resource for many years to current and future colleagues engaged in this exciting and rapidly developing specialty.

Daniel Ellis, London, UK  
Matthew Hooper, Adelaide, Australia  
June 2009
Acknowledgments

The authors would like to thank the following colleagues and institutions, without whom the production of this text would not have been possible:

Dr Jane Cocks
Dr Gareth Davies
A/Prof William Griggs
Dr Tim Harris
Dr Stephen Hearns
Dr David Lockey
Dr Stefan Mazur
A/Prof Andrew Pearce
Mr David Tingey
Dr David Zideman
and
Dr Matt Gunning (Question 28)
Dr Zane Perkins (Question 28)
Dr Mark Shirran, CareFlight Medical Services, Queensland, Australia (Appendix 4)
Dr John Trenfield (Appendix 1 – thoracostomy, thoracotomy, vascular access, escharotomy)

Helicopter Emergency Medical Service (HEMS London), UK
The Essex and Herts Air Ambulance Trust, UK
South Australian Retrieval Services (Royal Adelaide Hospital, Flinders Medical Centre, Women’s and Children’s Hospital)
MedSTAR Emergency Medical Retrieval Service, South Australia
CareFlight Medical Services, Queensland, Australia

Picture acknowledgments

The pictures in the text belong to the authors unless indicated below:

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Section B

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31.1 Dr Stefan Mazur, CareFlight Medical Services, Queensland
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40.1 Dr Zane Perkins
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Section C

45.1 CareFlight Medical Services, Queensland
50.1 A/Prof William Griggs, MedSTAR Emergency Medical Retrieval
50.2 A/Prof Andrew Pearce, MedSTAR Emergency Medical Retrieval

Appendix 1
Thoracotomy: London HEMS
Thoracotomy tools: Dr Peter Temesvari, Essex and Herts Air Ambulance Trust
Thoracostomy: London HEMS
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Dan graduated from the medical schools of Guy’s and St Thomas’ Hospitals (University of London) and directed his initial training towards a career in emergency and critical care medicine. He gained early experience in pre-hospital medicine while working in the ambulance service in Jerusalem and then as a military doctor in Israel. After returning to the United Kingdom, he continued basic and advanced level training in emergency and intensive care medicine. During this time, he was able to continue working in pre-hospital and retrieval medicine as a specialist registrar in pre-hospital trauma care with the London Helicopter Emergency Medical Service (HEMS) followed by a post as paediatric intensive care retrieval fellow with the Children’s Acute Transport Service (CATS) in London. Throughout this time, Dan was an active member of the British Association for Immediate Care (BASICS) in London and was involved in two major incidents, including the terrorist attacks in London on 7 July 2005. After spending a year as a consultant in Emergency and Pre-hospital and Retrieval Medicine in Australia, he returned to the United Kingdom to take up the role of lead clinician for the two aircraft of the Essex and Herts Air Ambulance. In this post, he has overseen the conversion of Essex from a double paramedic service to a paramedic/doctor service as well as the inauguration of the new Herts service. Dan has also been actively involved in discussions to provide London and the Home Counties with a centralised critical care retrieval service by utilising the existing pre-hospital teams and resources. He has also spoken at local, national and international conferences on major incidents, pre-hospital and retrieval medicine and critical care.

Dan is married with two children and lives in London.
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Matt graduated from the University of Adelaide School of Medicine and commenced basic and advanced emergency medicine training in Adelaide, Perth and South-East Queensland. He developed a keen interest in pre-hospital care and aeromedical retrieval during this time and continued this interest over two years in the United Kingdom initially as a paediatric intensive care retrieval fellow with London’s Child Acute Transport Service (CATS) and then as a specialist registrar in pre-hospital trauma care with the London Helicopter Emergency Medical Service (HEMS). In 2002, he was awarded the gold medal by examination for the Diploma in Immediate Medical Care from the Royal College of Surgeons of Edinburgh before returning to Australia to complete Fellowships with both the Australasian College for Emergency Medicine and the Joint Faculty of Intensive Care Medicine. Before returning to Adelaide, Matt was involved in the redevelopment of retrieval services in Queensland as the Regional Director of Operations and Training for CareFlight Medical Services.

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Lead Clinician for Emergency Medical Services, 2012 Olympic Games, London, UK
Introduction

Approach to *Cases in Pre-Hospital and Retrieval Medicine*
This case-based book uses real pre-hospital and retrieval situations presented in a question format, followed by an extensive discussion. Each question and discussion consists of approximately 1000–2000 words and is usually illustrated with a photograph. The cases have been arbitrarily divided into those with a predominantly pre-hospital theme, those based around retrieval medicine and a third section focusing on service development and special circumstances. In addition, a series of appendices provides information of use to pre-hospital and retrieval practitioners. Each case can be read as a ‘stand-alone’ scenario although each section has a structure that builds on the key concepts discussed in earlier cases. As such, each section is ideally approached in numerical order.

Practical points
This book is primarily designed for the ‘hands-on’ pre-hospital and retrieval doctor. It is also likely to be of significant interest and use to a broad range of emergency medical and non-medical personnel. Each question is written with the assumption that the doctor forms part of a highly trained pre-hospital and retrieval (PHR) team. Although the composition of such teams varies widely internationally, the key learning points for each question are relevant to all professional medical, paramedical and nursing personnel engaged in this challenging and unpredictable area of practice. Medical practice will also vary regionally. For this reason, this book does not always provide extensive detail regarding precise therapies, clinical guidelines and drug doses. It is not a definitive text on emergency or critical care medicine. Instead, it provides a scenario-based approach to highlight key areas of pre-hospital and retrieval medicine.

Tasking and clinical coordination
PHR teams may be tasked directly by the local ambulance service. Many are tasked by a dedicated tasking and clinical coordination service that provides senior medical oversight and assesses each potential situation before dispatching the team. For the purposes of this book, the PHR team will always have a dedicated person tasking them and acting as the communications hub throughout the mission. For ease of reference, this person will be referred to as the coordinator and the organisation in which they work will be the tasking agency.

Sample question format
Most cases in this book follow a standard format to allow consistency.

Incident
This section presents a brief synopsis of the task for which the PHR team has been activated. This may range from the pre-hospital mechanism of injury through to the presenting patient illness, physiologic parameters and location. The information
Cases in Pre-Hospital and Retrieval Medicine

available during the early stages of pre-hospital and retrieval tasking is often sparse. To provide the reader with a sense of realism, this is reflected in the information made available in the synopsis.

**Relevant information**

This section is usually divided into four sub-headings:

1. Aircraft: a description of the aeromedical resources available on the day. Options may include rotary wing, fixed wing, both or neither. If available, a road transport platform may be identified instead. As all aircraft are different, specifications will only be provided when relevant to the question.

2. Local or ground resources: in most pre-hospital and retrieval environments, other resources will be available. In the pre-hospital environment, this will include a mixture of Fire & Rescue, Police and Ambulance service teams. In the retrieval environment it will usually refer to resources available at the local medical facility.

3. Retrieval options/destination: regional resources and geography play a major role in the daily clinical and logistic decision making required of the coordinator and PHR team. By providing details of the nearby hospitals and their facilities, the reader will be able to decide which facility is most appropriate. This may involve bypassing the nearest hospital for one better able to manage the patient’s acute or ongoing care. In cases where the receiving hospital is predetermined, information regarding flight times and aircraft endurance are supplied when relevant.

4. Other: key information not included under the above headings can be given in this section. For example, the weather often plays a key role in the pre-hospital and retrieval environment. Additionally, the time of day and traffic conditions may be relevant points for consideration.

**Questions and discussion**

Questions, answers and discussion will be structured to lead the reader through key learning points in a realistic fashion. Subsequent cases will introduce new material whilst reinforcing key topics and themes (e.g. scene safety or aviation physiology) introduced previously. Where appropriate, references to other cases are given to allow similar themes to be explored.

**Key points**

A summary of the key learning objectives will feature at the end of most cases. In addition, references and an additional reading list have been added if required.

**Glossary and key to cases**

A glossary of definitions has also been included to clarify terminology (e.g. what is meant by the term ‘general hospital’). The glossary also includes a list of common acronyms used in the text.

A full list of cases and key topics covered can be found at the end of the book. The information in this section is likely to suggest the answer to specific questions so should be used for rapid reference or review following completion of all cases.
Incident
A car has collided with a motorcycle 15 minutes ago at an estimated combined speed of 80 km/h (53 mph). The motorcyclist is trapped.

Relevant information
- **Aircraft:** Rotating
- **Ground resources:** One land ambulance. Two ambulance response vehicles. Police and Fire & Rescue Services
- **Retrieval options:** General hospital 15 minutes by road. Major trauma hospital 30 minutes by air
- **Other:** Friday 17: 20 hours

Question
1.1 Outline in detail your approach to the scene.
**Discussion**

1.1 In brief, the approach to the scene offers an opportunity to:

- Identify potential hazards.
- Briefly ‘read’ the likely mechanism.
- Identify patient numbers, distribution and acuity of injury.
- Commenceformulating a pre-hospital plan.

Scene assessment is critical to ensuring team, scene and, ultimately, patient safety. It begins as soon as details of the task become available. The tasking agency may have access to further information which may be forwarded to the team en route.

**Arrival by air**

Approaching the scene from the air offers considerable advantages over a road response. The entire Helicopter Emergency Medical Service (HEMS) crew (of which the pre-hospital and retrieval team (PHR) are an integral component) should utilise this opportunity to both study the incident scene from above and ensure all potential aviation hazards are communicated clearly and briefly. This should be done by referencing a clock face (where the nose of the aircraft is at 12 o’clock) and using the terms ‘high’ or ‘low’ to point out hazards. Landing site selection is at the discretion of the pilot, who is ultimately responsible for aircraft safety. A landing site may be pre-arranged with on-scene emergency services to facilitate landing but the final decision always rests with the pilot.

Key points (note many of these in the above scene) to look out for from the air in the HEMS environment are detailed in the box below.

<table>
<thead>
<tr>
<th>Key points to note in the HEMS environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hazards</strong></td>
</tr>
<tr>
<td>• Aviation (power lines, wires, fences, trees, light posts, towers and loose objects).</td>
</tr>
<tr>
<td>• Scene (moving vehicles, open roads, fire hazards and scene topography including heights).</td>
</tr>
<tr>
<td><strong>Emergency services on scene</strong></td>
</tr>
<tr>
<td>• Ambulance resources (may alter what you will take with you from the aircraft, e.g. additional oxygen, splints or other equipment).</td>
</tr>
<tr>
<td>• Other services (particularly note the absence of Fire &amp; Rescue and/or Police, thus requiring additional team vigilance).</td>
</tr>
<tr>
<td><strong>Mechanism</strong></td>
</tr>
<tr>
<td>• Deformation, debris spread, tyre marks, distance between involved vehicles, vehicular mass and speed limit of road.</td>
</tr>
<tr>
<td><strong>Scene geography</strong></td>
</tr>
<tr>
<td>• Number and position(s) of potential casualties.</td>
</tr>
<tr>
<td>• Areas for safe access, on scene assessment, procedures and egress.</td>
</tr>
</tbody>
</table>

In any pre-hospital emergency situation, scene safety is the primary concern and, as detailed above, plans for approaching the scene should be made on or prior to landing. The PHR team should adopt the ‘safe self, safe team, safe scene, safe patient’ approach.
Arrival by road
The PHR team will regularly arrive at a scene by land vehicle, usually driven by one of the team. Advanced driving using emergency lights and sirens is a complex skill that requires training and regular review by a qualified instructor. On arrival at scene, ensure the sirens are switched off promptly (when safe to do so) to avoid disrupting teams already on the scene. Park close to the scene but do not obstruct the access or egress of other emergency service vehicles. Try to park in the ‘fend off’ position (at an angle to the scene) to improve safety in the event of oncoming traffic striking the rear of your vehicle. Leave emergency lights on if yours is the first vehicle on the scene but bear in mind the vehicle battery could be exhausted if the scene time is prolonged or if the team escorts the patient to hospital in a different vehicle. Take all the necessary equipment initially as returning to the vehicle may become difficult if the scene becomes more complicated.

Personal and team safety
The PHR team should arrive at the scene together and be adequately attired. Each member requires appropriate personal protective equipment (PPE). The team must be adequately trained and audited to ensure they are able to account for themselves in the pre-hospital environment.

Scene safety
Following vehicle accidents such as the one above, the Fire & Rescue Service are the lead safety authority and must be consulted first for advice on scene safety. Identify the Fire & Rescue Service team leader (either by uniform/helmet markings or by direct questioning) and specifically ask whether or not the scene is safe to enter. If these personnel have deemed the scene unsafe, the PHR team should not proceed under any circumstances. For incidents involving violent crime and/or assault, the Police Service will be in charge of the scene and should similarly be approached and questioned about scene safety. It is common for the police to set up a rendezvous point (RVP) away from the primary incident where medical teams and other services can gather. This enables the police to make the scene safe prior to the arrival of additional medical resources. Again, the PHR team should not proceed to the scene before it has been declared safe to do so.

Standing back from the scene may be harder than it seems, especially if seriously injured patients are visible. However, even in these circumstances, the PHR team should inform the Fire & Rescue or Police service team leader they are ready to enter the scene on their instruction. They should then stand back until the scene is declared safe. Experienced PHR teams may be able to make suggestions to the relevant team leader (e.g. information obtained during aerial scene assessment) but the final decision rests outside the team.

If the PHR team are first to arrive on the scene (i.e. before the Fire & Rescue or Police services) then they must make an independent assessment of scene safety. Actively developing personal and team situational awareness is critical in such circumstances.

For a road vehicle crash, one such assessment would be:

Scan the scene as you approach to observe
- Traffic flow.
- Scene topography.
Fallen power lines.
Smoke.

Stop about 5 metres from the scene and analyse what you see in depth
- Liquid on he floor.
- Smell of petrol.
- Stability of vehicle.
- Other features.

Ensure appropriate resources en route
- Communicating with asking agency/other services.

Enters scene with caution
- Reassess scene frequently.

Other incident scenes may require a level of assessment beyond even the most experienced PHR team (e.g. building collapses, terror attacks) and, in such circumstances, the best response will be to make a cursory inspection and wait for expert support. Entering an unsafe scene to look for injured people must be avoided. Patients who are clearly visible within the scene and who appear in extremis pose a particular problem. The PHR team leader should weigh up the risk–benefit of emergency (‘crash’) extraction versus waiting for expert help to arrive (see Case 4).

When the fire service or police arrive, the PHR team leader should hand over the scene assessment and formal scene control.

It is important to note that although safety takes absolute priority, forensic evidence does not and the PHR team should not be prevented from entering a safe scene simply to preserve evidence. Even if the victim is presumed to be deceased, the PHR team should usually be allowed access to confirm death. It is the responsibility of the PHR team to make every effort to preserve the scene for the police and nothing should be moved unless necessary to save life or limb.

Patients safety
The assessment of patient safety has a great deal of overlap with the assessment of scene safety but is included to encourage the team to focus on the patient and the immediate environment. Removing the patient from danger to a safe area of the scene with improved patient access is both a priority and the first step in any therapeutic intervention.

Key points
- A ‘safe’ approach is critical:
  - Safe self and team.
  - Safe scene.
  - Safe patient.
- Scene assessment from the air offers many advantages.
- Adequate PPE is a mandatory requirement.
- Liaise early with the lead safety authority.

Additional reading
**Incident**
A 45-year-old male construction worker on a building site has been struck on the head by a scaffold pole. The patient is confused and combative and access to scene is by crane only.

**Relevant Information**
- **Aircraft:** Rotary-wing landing site 1 km (0.6 miles) away
- **Ground resources:** One land ambulance. Police Service
- **Retrieval options:** Major trauma hospital 25 minutes by road
- **Other:** Senior construction-site personnel available on scene

**Questions**
5.1 What is your initial pre-hospital plan?
5.2 Briefly describe your approach to this particular scene.

Clinical information:
- P1 10.
- BP 140/80 mHg.
- GCS 13 (E4, V4, M5).
- Confused, ndc combative.

5.3 Discuss the different options for managing this patient’s airway highlighting, the ‘pros and cons’. Give your final decision.
5.4 How will you retrieve this patient to the receiving hospital?
Discussion

5.1 Scene
Note that this is an atypical scene. The risks of working at height should be considered.

Patient
Getting a confused and combative adult male off a roof will be challenging. The requirement for pre-hospital anaesthesia is a distinct possibility. The patient will also require spinal immobilisation.

Destination
This should be to a neurosurgical centre at least. This job is going to take some time regardless of the efficiency of the team.

5.2 There are clear safety implications for the PHR team in this scenario. Locate the most senior construction site personnel available. Establish that the only way to access the patient is via the crane (e.g. ask questions, such as: are there stairs or a builder’s elevator on the side of the building? How safe is the location of the patient – near the edge, weak floors etc? What extra PPE is required – are fall arrest harnesses appropriate?).

Remember scene safety is the PHR team’s responsibility. If the scene is too unsafe for the team to enter, the patient will have to be brought to you by the builders in the safest way possible. You can assist in this process by offering advice verbally as required. If time allows, the Fire & Rescue Service may be called to assist in planning a more formal extrication.

5.3 Essentially, the different options in this patient’s case relate to whether or not rapid-sequence induction (RSI) and intubation is appropriate. Pre-hospital RSI is a difficult and complex procedure even for the skilled practitioner. Correct patient selection is paramount. Suggested indications for pre-hospital RSI are outlined in the box below.

<table>
<thead>
<tr>
<th>Suggested indications for pre-hospital RSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Actual or impending airway compromise.</td>
</tr>
<tr>
<td>• Ventilatory failure.</td>
</tr>
<tr>
<td>• Airways oiling.</td>
</tr>
<tr>
<td>• Unconsciousness.</td>
</tr>
<tr>
<td>• Unmanageable or severely agitated patients after head injury.</td>
</tr>
<tr>
<td>• Anticipated clinical course.</td>
</tr>
<tr>
<td>• Humanitarian indications.</td>
</tr>
<tr>
<td>• Flight or pre-hospital safety issues.</td>
</tr>
</tbody>
</table>

Always perform an on-scene risk-benefit analysis on each and every case that you consider for RSI. Points to consider in such an analysis include:

- PHR team skills, experience and training.
- Available skilled assistance (ideally RSI should not be a solo procedure).
- Anticipated airway difficulty.
Proximity to hospital and required transport times.
Patient cuity and physiologic instability.
Mode of transport (road transport may allow more flexibility).

A sensible risk–benefit analysis will prevent pre-hospital RSI from becoming ‘automatic’ for certain groups of patients. In broad terms, pre-hospital RSI should be viewed as a three-stage procedure with each stage carrying equal importance. If the PHR team lacks the skills required for any stage, then pre-hospital RSI should be reconsidered.

<table>
<thead>
<tr>
<th>Three stages of pre-hospital RSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1: Patients election.</td>
</tr>
<tr>
<td>Stage 2: Technical challenge of drug-assisted tracheal tube placement.</td>
</tr>
<tr>
<td>Stage 3: Continued initial management of the critically injured ventilated patient.</td>
</tr>
</tbody>
</table>

In this particular case, there are other issues that need to be considered.

In favour of RSI
- Safety: The crane basket seems to be the only way down. It is not acceptable to place the safety of the patient and the team in jeopardy by trying to move a combative patient in this way. The patient is unlikely to be rational or co-operative and a struggle in the crane basket could be disastrous. In addition to the crane issue, the patient has either a road or helicopter trip ahead before he arrives at the receiving hospital.
- Patient: In the HEMS pre-hospital trauma environment, an adult with a GCS of 13 or 14 following head injury has a significant chance of intracranial pathology. Early control of the airway and ventilation will facilitate improved cerebral protection and avoid common secondary insults. On arrival at the trauma hospital, the patient will require a head CT scan. There is a good chance that he will also require sedation and airway control for this procedure.

Against RSI
- Safety: Moving the patient following RSI is going to be considerably more difficult due to the high level of monitoring required. Will the immobilised ventilated patient and all the monitoring, oxygen and other equipment fit in the crane basket? In addition, a member of the PHR team will need to travel with the patient as well as all the pre-hospital equipment.
- Patient: In view of the patient’s precarious location, is RSI technically possible? Can 360 degree access be obtained in this situation?

Bottomline
- The risk–benefit approach illustrated above should be performed for each patient to be sure that the PHR team has fully analysed each case on its merits. In this case, the patient should be anaesthetised where he is and then evacuated from the roof.
- Any service that performs pre-hospital RSI should be audited specifically to examine failed intubation rate, number of attempts, oxygen saturations and other measures of dynamic physiologic stability before, during and after the procedure. This will ensure the risks of RSI do not outweigh the benefits at each instance.
5.4 Roofto ground

In transferring the patient from the roof to the ground, the general rules for transporting the ventilated patient apply (see Case 23). In this instance, a member of the PHR team must remain with the patient at all times. It is unlikely that there will be absolutely no room for anyone but the patient in the crane basket. However, if the team found themselves in such a position, other options may be available such as a vertical-winch rescue utilising an appropriate rotary wing aircraft (see Case 45) or advanced roping vertical-rescue techniques. If these options are not available, the PHR team could consider splitting up after the RSI and having one member on the ground and the other on the roof. In this setting, the patient must be adequately secured and packaged with optimised physiology on the transport ventilator. Lowering of the basket should be as swift as practicable. Communication should occur between the team by radio or mobilephone.

Ground to hospital

This patient should go by road to the major trauma hospital. The helicopter is 1 km (0.6 mile) away from the building site and, in either case, the patient will need to be packaged in an ambulance. Driving this distance and then transferring the patient to the helicopter, repackaging and flying to the trauma hospital is unlikely to be quicker than simply going straight from the building site by road. Police Service personnel are available and may be asked to provide an escort, particularly if the traffic is bad. The decision to provide such an escort is made by the Police Service and pressure must not be applied on officers by the PHR team.

Do not forget to communicate your decision with the pilots and the tasking agency.

Key points

- All medical interventions in the pre-hospital environment are relatively high–risk and require careful risk–benefit analysis.
- The performance of pre-hospital RSI is a three-stage procedure.
- Patients requiring complex extrication and pre-hospital RSI pose specific challenges.

References

SECTION B

Retrieval theme
Incident
A 56-year-old woman has collapsed and presented by ambulance to a general hospital without on-site neurosurgical support. On admission, she was deeply unconscious and required intubation and ventilation in the Emergency Department. Examination findings at that time revealed bilateral brisk reflexes, hypertension (BP 180/100 mmHg) and small, non-reactive pupils. A CT head scan has now been arranged, which will require the patient to be transported to the radiology department, which is located on another level of the hospital building.

Relevant information
- Regional resources: Neurosurgical centre 300 km (185 miles) away

Questions
23.1 Outline your plan for safe patient transfer to and from the radiology department.

23.2 What does the CT head scan reveal? What should now occur?
23.3 Outline how the inter-hospital transfer of this patient to the neurosurgical receiving hospital 300 km (185 miles) away differs from the previously required intra-hospital transfer for CT head scan.
Discussion

23.1 Intra-hospital transport of critically ill patients occurs frequently. Transports are usually required to facilitate critical investigations and interventions or to move the patient from one critical-care area (e.g. Emergency Department) to another (e.g. ICU). Critically ill patients with minimal or no physiologic reserve undergoing such transports are at risk of clinical deterioration and adverse events are well reported\(^1\).

To minimise potential adverse events, a structured approach for all intrahospital critical-care transports is required. Intrahospital transport guidelines and protocols may vary regionally. A broad outline is detailed below.

Risk–benefit assessment

Patients undergoing invasive ventilation and who require high levels of intensive care support should not be transported for non-urgent interventions or investigations. In this scenario, the need for urgent imaging, potential intervention and ongoing care outside the Emergency Department clearly supports the requirement for patient transport.

Patients stabilisation

- Although acute threats to life have been addressed, a definitive diagnosis is unclear. Further investigation is therefore required before any therapeutic options (if any) are considered. Thus, in this scenario, patient transport for definitive investigation can be considered part of the stabilisation process. Prolonged periods of time in the Emergency Department performing multiple invasive procedures and attempting complete physiologic normalisation are not appropriate.
- Clinical reassessment should occur swiftly, systematically and, whenever possible, with the patient already supported by the equipment that will be used during transport.
- The airway should be checked and secured, endotracheal suction performed, ventilation and oxygenation optimised, adequate and patent vascular access secured and drainage devices measured and emptied. Sedation and analgesic requirements should be addressed and any drugs required for transport (including additional infused agents) pre-drawn and labelled for immediate use.
- Neuroprotective care should be provided, despite the current undifferentiated nature of the presentation (see Case 10). Specifically, hypotension, progressive hypertension, hypoxia and hypercarbia or hypocarbia should be aggressively avoided.
- Ensure that the patient clinical record remains with the team caring for the patient at all times.

Communication and coordination

Handover of care

- This will be required if the transport team are not the team currently caring for the patient. Clinical handover should be between nominated team leaders and be clear, concise, structured and documented.
The assembled team (see below) should reassess the patient’s clinical condition, need for transport and predicted clinical requirements. Hospital-based protocols and pre-defined check lists assist significantly and avoid oversight of simple but critical requirements, such as adequate oxygen and available suction for the transport.

The initial receiving unit will be the radiology department. Communication should confirm an agreed time for the investigation. This will allow the team to arrive with enough time to transfer the patient safely onto the CT scan machine. Following the investigation, consider again the receiving unit, which may vary dependent upon the CT findings. Possibilities include the Emergency Department, the ICU or an operating theatre. All relevant units should therefore be made aware of the pending transport and investigation, as well as the working diagnosis and clinical plan.

If not already involved, a senior neurosurgical doctor and radiologist should be contacted.

This should be decided prior to departure. Where possible, the route should avoid common public access areas, lifts and clinically isolated, poorly lit, exposed, narrow (limiting 360 degree patient access) or cramped areas.

As a team, consider and verbalise the worst-case scenario. Plan how you will respond should this occur. This may include a plan to move to the nearest appropriate area for resuscitation, which may vary during the journey.

A fully charged, dedicated and serviceable mobile phone should be carried during the transport. This will be required should there be a need to call for urgent assistance, or in order to facilitate ongoing clinical communication.

A team consisting of at least two healthcare professionals should be free from other duties. Both team members should be thoroughly familiar with the transport process, equipment and environment. The team should possess the requisite skills and knowledge to independently manage critically ill patients in transit and to anticipate and deal with anticipated emergencies.

Assistance with safe patient, trolley and equipment movement will be required. Hospital orderlies or security staff are often part of the team and should be included in all briefs and contingency planning.

Transport equipment should be:

- Regularly checked and serviceable.
Fully charged, with power cords accessible to facilitate use of mains power in the event of delay.

- Lightweight, robust and ideally standardised throughout the hospital.
- Securable in transit (not resting on the patient) but readily accessible.
- Relevant to the clinical requirements of the patient and safe in the required area (e.g. magnetic resonance imaging).
- Dedicated for the transport (transport ‘bridges’ or gantries are commonly used).

In addition:
- Dedicated transport packs or boxes ensure safe carriage of consumable items and resuscitation equipment and drugs.
- Equipment required for emergency airway management (e.g. bag valve mask, laryngoscope, airway devices and endotracheal tubes) should be immediately available.
- In this case, the available equipment in the radiology department should be clarified:
  - Does it meet the required standards, or will the patient need to remain on the transport equipment?
  - Are there compatible oxygen/air outlets or will ongoing portable oxygen be required?

Monitoring
- As a minimum, intubated and ventilated patients requiring intrahospital transport should have the following monitoring instituted:
  - Continuous ETCO₂.
  - Continuous SaO₂.
  - Continuous invasive or intermittent non-invasive BP.
  - Continuous 3-lead ECG.
- Ideally, a cardiac monitoring device should also provide cardiac defibrillation and external cardiac pacing capacity. If not, an additional device that does provide these functions should be secured and available in transit.
- Patients requiring transport with more advanced monitoring in situ should be considered on a case-by-case basis. For example, ongoing ICP monitoring is critical to ensure avoidance of profound unmonitored falls in cerebral perfusion pressure in an ICU patient with a severe head injury whereas pulmonary artery pressure monitoring may be excluded from the transport requirements in the haemodynamically stable patient.

Documentation and review
- Contemporaneous and concise documentation of the transport process is mandatory.
- An audit of all transports should occur on a regular basis and incidents or events should be captured within the hospital or transport unit’s quality and safety framework.
- The initial and ongoing educational requirements of all staff involved in intrahospital transports should be addressed.
23.2 The CT head scan reveals blood within the subarachnoid space with evidence of acute hydrocephalus. This is a neurosurgical emergency, which requires immediate consultation with a specialist neurosurgeon regarding ventricular decompression. The CT images will need to be viewed by the neurosurgeon at a distant location. A concise description of the historical events and the patient’s current clinical condition should be provided. In this setting, even fixed and dilated pupils should be interpreted with caution as complete reversibility has been described.

The key question at this point relates to how to ensure ventricular decompression occurs as rapidly and safely as possible. There may be a surgeon other than a neurosurgeon at the referral centre with the clinical skills to perform such a procedure. Alternatively, the rapid transport of a neurosurgeon with appropriate equipment to the referral facility may be the best option. Failing this, the patient will require emergency inter-hospital transport.

23.3 Inter-hospital transport of patients also occurs frequently. The term ‘medical retrieval’ refers to a dedicated team responding in order to provide such transports. Like intra-hospital transports, a structured approach will ensure potential adverse events are minimised and much of what is outlined above is applicable here. However, when compared to intra-hospital transports, inter-hospital medical retrieval may differ in terms of both logistic and clinical complexity.

Risk–benefit assessment
This assessment now includes aviation and other logistic considerations. For example: What is the weather like? Are the roads busy and congested? Which aircraft or other transport platforms are available? Are there any patient issues that would preclude non-pressurised air transport? (see Case 24)

Patients stabilisation
Now that the diagnosis is clear and the therapeutic requirements are known, the required transport again can be seen as part of the therapeutic process.
Prior to the arrival of the retrieval team, the referral hospital should establish invasive arterial access for continuous pressure monitoring. An indwelling urinary catheter and nasogastric tube should also be placed. Central venous access should be secured if vasoactive infused agents are required. Neuroprotective therapy should be maintained. If possible, consider placing the patient in a 30 degree head-up position.

Communication and coordination
- A dedicated communication and coordination process staffed around the clock is required. Ideally, this should be centralised, accessed by a single number and provide both high-level clinical input and logistic coordination of retrieval teams and transport platforms.
- Such a process should ensure clinical oversight is vested in an appropriately qualified medical practitioner.
- Early advice to the referral facility is a key component of this process.
The referral and receiving destinations, retrieval team(s) and transport agencies require clear communication, including the rapid notification of delays or variations to the transport plan. Given the required transport distance of 300 km (185 miles) and the clinical requirements of the patient, rapid-rotary wing transport is preferred. However, the final decision of the most appropriate transport platform will be influenced by a large number of variables (see Case 24).

Staff

Clinical
- There should be a dedicated transport or retrieval team trained in the clinical and safety aspects of retrieval medicine. They should be thoroughly familiar and experienced with both the clinical requirements of the patient and the out-of-hospital medical transport environment, including relevant aviation issues.
- The team should be adequately attired and have appropriate PPE for air medical operations.

Non-clinical
- The air crew or road ambulance personnel are key members of the transport or retrieval team. Highly functioning retrieval services actively develop such extended teams.

Equipment
In addition to the issues discussed in the first part of this case (Question 23.1), equipment for air medical transport (including packs and monitoring devices) must be approved for such use, able to be adequately secured during transport (whilst remaining accessible), robust enough to withstand the out-of-hospital and aviation environments and ergonomically designed to ensure safe carriage and loading. The total weight of all medical equipment should be kept to a minimum. A suggested equipment list can be found in Appendix 2.1.

Sufficient batteries should be carried to comfortably last the entire trip. Oxygen requirements at altitude can be anticipated (see Case 24, page 111) and total oxygen required should be carefully calculated (see Case 24, page 110). It is good practice to double the anticipated battery and oxygen requirements to cater for unexpected delays.

Documentation and review
- Contemporaneous and concise documentation of the transport process is mandatory.
- Audit and quality assurance activities (including incident and event reporting) need to include the communication and coordination process, logistic and aviation considerations and patient outcomes, in addition to the clinical care delivered to the patient in transit (see Case 48).
- Regular multidisciplinary audit provides an effective whole-of-service tool in regard to meeting these audit and quality assurance requirements.
- Feedback both from and to the referral and receiving staff is an important additional consideration.
Oxygen requirements during transfer

2 \times \text{transport time in minutes} \times ([\text{MV} \times \text{FiO}_2] + \text{ventilator driving gas})

\text{MV} = \text{minute volume}\
\text{FiO}_2 = \text{inspired oxygen fraction}

\text{Ventilator driving gas is dependent on ventilator make (e.g. an Oxylog 3000 [Drager] uses 0.5 litres per minute)}

(Note the transport time is doubled for safety)

Sample calculation for retrieval of 1-hour duration:
\text{MV} = 6 \text{ litres per minute}\
\text{FiO}_2 = 0.6

\text{Ventilator driving gas} = 0.5 \text{ litres per minute}

2 \times 60 \times ([6 \times 0.6] + 0.5)\
\rightarrow 120 \times 4.1 = 492 \text{ litres of oxygen}

Key points

- Critically ill patients are at risk of clinical deterioration while in transit between critical care areas and a risk–benefit assessment is required when considering any patient transport.
- Risks can be minimised by applying a standardised approach to patient transfer.
- The movement of patients between hospitals over larger distances utilising aircraft or road vehicles requires a highly functioning communication and coordination process combining clinical and logistic considerations.

Reference


Additional reading

Appendix 3 - Transfer checklist.


Incident
Following a fall from farm machinery, a 40-year-old female has intracranial haemorrhage and spinal injuries and requires retrieval from a general hospital. She is intubated and ventilated with the following ventilatory settings:
- Tidal volume 450 mL.
- RR 12 breaths per minute.
- Positive end expiratory pressure (PEEP) 5 cm H₂O.
- Inspired oxygen 28%.

Clinical observations:
- P 85.
- BP 140/80 mmHg.
- SaO₂ 98%.

Relevant information
- Aircraft: Fixed-wing and rotary-wing aircraft available
- Local resources: One land ambulance
- Retrieval options: Specialist neurosurgical and spinal hospital 320 km (200 miles) away
- Other: Ambient conditions: Heavy rain 15°C (59°F)

Questions
24.1 Discuss the key points of flight physiology.
24.2 What are the key differences between fixed-wing and rotary-wing retrievals?
24.3 Which transport platform would you choose in this scenario?

Discussion
24.1 Gas expansion
Boyle’s Law, which relates to the expansion of gases, is the principal gas law to remember in the context of flight physiology. Essentially, gas will expand as altitude increases and atmospheric pressure decreases. As altitude decreases, the opposite occurs. Therefore, during an aeromedical evacuation, any gas in an enclosed space will try to expand. A change in altitude from sea level to 8000 feet (2500 metres) will expand an enclosed volume of gas by 35%. Relevant gas-filled structures that may be affected are listed in the box over the page. Slow changes in altitude can minimise the effects of gas expansion.

Hypoxia
The relevant gas law in this instance is Dalton’s Law. As altitude increases and atmospheric pressure decreases, the partial pressure of oxygen will fall at the alveolar interface unless supplemental oxygen is administered. A fall in alveolar oxygen partial pressure results in lower oxygen delivery to the tissues. Oxygen saturation for healthy
Cases in Pre-Hospital and Retrieval Medicine

### Gas-filled structures

#### Physiological body spaces
- Middle ears.
- Facial sinuses.
- Stomach and intestine.

#### Pathological body spaces
- Pneumothoraces.
- Intracranial air.
- Surgical wounds.
- Dental caries.
- Intravascular bubbles (see Case 16).

#### Equipment
- Endotracheal tube cuffs.
- Pressure bags.
- Air-in-fluid bags, giving sets or pressure intravenous monitoring lines.
- Pneumatic or vacuum splints (the latter will lose rigidity at altitude).

Adults will drop to around 94% at 6000–8000 feet (1800–2500 metres), which is the usual cabin pressure for commercial aircraft. This drop will be more significant in patients with underlying pulmonary or vascular disease or conditions with reduced oxygen carrying capacity (i.e., anaemia).

Oxygen requirements at altitude can be predicted (see box on next page). The administration of oxygen can usually be controlled by monitoring oxygen saturations or blood oxygen partial pressure via blood gas assessment. Note that a patient requiring 70% inspired oxygen to avoid hypoxia at sea level would require 80% inspired oxygen at 4000 feet (1200 metres) to maintain a sea level equivalent partial pressure of oxygen. Above 10,000 feet (3000 metres), the patient would become hypoxic even if the inspired oxygen concentration was 100%.

### Management issues

In addition to administering supplemental oxygen, hypoxia can also be prevented by altering cabin pressure or flying below around 2000 feet (600 metres). On fixed-wing air ambulances, it is possible to fly with the cabin pressurised. This may be partial (e.g., to 8000 feet [2500 metres] equivalent even if the aircraft altitude is 35,000 feet [11,000 metres] or complete [sea-level cabin]). A sea-level cabin is usually possible if the anticipated cruising altitude is below 20,000 feet (6000 metres). Although cabin pressurisation will prevent gas expansion and hypoxia, overall aircraft performance is reduced (ground speed and range) and fuel use is increased. A brief discussion with the pilot will confirm cabin pressurisation feasibility. Cabin altitude should be documented on the medical notes. Remember, the patient’s location may not be sea level, in which case cabin pressure need only match that at the departure location.

At altitudes below around 2000 feet (600 metres), it is unlikely that serious altitude-related problems will occur (including the often feared complication of occult pneumothorax expansion). At higher altitudes (usually associated with longer transport times), close attention should be paid to the patient and the equipment affected by pressure changes. In
the ventilated patient, any pneumothoraces must be checked for and drained before departure. A nasogastric tube should be passed in order to decompress the stomach. The tracheal tube cuff should be inflated to minimally occlusive volume at the altitude of departure then checked with a manometer and adjusted accordingly following ascent and descent.

Pneumatic splints can be affected by altitude, which potentially compromises limb circulation. Conversely, vacuum splints or mattresses will lose stiffness at altitude. Air in intravenous fluid bags can expand at altitude and this may speed up flow while the opposite applies on descent. Some ventilators can be affected by altitude with increases in certain parameters (e.g. tidal volume) occurring as barometric pressure falls. Decompression illness is rare, only being an issue if an emergency loss of cabin pressure occurs at high altitudes (so called explosive decompression). However, scuba diving 24 hours before a flight can lead to decompression sickness at commercial pressures of 6000–8000 feet (1875–2500 metres).

Other stresses of flight (that can affect patients and crew) include:

- Gravitational forces during turns, take-off and landing can cause transient haemodynamic compromise (e.g. by venous pooling). Patient position in the aircraft can help in this aspect (e.g. horizontal placement).
- Vibration forces, especially in rotary-wing aircraft, can affect the patient (e.g. clot disruption), passengers and equipment. Clinical examination is difficult and monitors may struggle to properly detect patient data.
- Turbulence can lead to motion sickness, fear and physical injury.
- Noise can be obvious, in which case hearing protection should be used but high-frequency noise such as from jet engines can be more troublesome and debilitating.
- Temperature in the cabin can usually be controlled but it is worth noting that external ambient temperature decreases by about 2°C (3.6°F) for each 1000 feet (300 metres) of altitude.
- Humidity in the air decreases at altitude and can lead to dehydration.
- Confined space and poor lighting within the cabin can compound the stress of aeromedical retrieval and will limit the ability to react to medical emergencies. Thorough preparation is the key to minimising such events.

### Relevant gas laws and oxygen requirements at altitude

<table>
<thead>
<tr>
<th>Boyle’s Law</th>
</tr>
</thead>
<tbody>
<tr>
<td>For a fixed amount of gas at a constant temperature, pressure and volume are inversely proportional (i.e. Pressure x Volume = constant).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dalton’s Law</th>
</tr>
</thead>
<tbody>
<tr>
<td>The total pressure exerted by a gaseous mixture is equal to the sum of the partial pressures of each individual component in a gas mixture.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Oxygen requirements at altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Current FiO₂ x barometric pressure 1) / (barometric pressure 2) = FiO₂ required.</td>
</tr>
<tr>
<td>FiO₂ = inspired oxygen fraction.</td>
</tr>
<tr>
<td>Barometric pressure 1 = current barometric pressure.</td>
</tr>
<tr>
<td>Barometric pressure 2 = barometric pressure at destination or altitude.</td>
</tr>
</tbody>
</table>
Choosing how to transport a patient to hospital is heavily influenced by resource issues, patient condition, weather, geography and distance.

In general, road transport is preferred for distances less than 100 km (60 miles) as it is most resistant to the weather and a road ambulance usually has a plentiful supply of medical equipment on board. Paradoxically, it can be quicker to do tasks within this 100 km radius by road even when aeromedical resources are available after factoring in the time taken to get the medical team airborne.

The differences between fixed-wing and rotary-wing transfers are summarised below.

<table>
<thead>
<tr>
<th>Aircraft</th>
<th>Fixed-wing</th>
<th>Rotary-wing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>Fast 320–800 km/h (200–500 mph)</td>
<td>Slower 200–280 km/h (125–175 mph)</td>
</tr>
<tr>
<td>Useful range</td>
<td>Variable but stops for refuelling unlikely</td>
<td>240–320 km (150–200 miles) refuels topslikely</td>
</tr>
<tr>
<td>Altitude</td>
<td>0–35,000 feet (0–10,700 m) (pressurised)</td>
<td>0–10,000 feet (0–3000 m) (unpressurised)</td>
</tr>
<tr>
<td>Cost</td>
<td>Cheaper</td>
<td>3–4 times more expensive</td>
</tr>
<tr>
<td>Response time</td>
<td>Slower (15–30 minutes)</td>
<td>Quicker (2–10 minutes)</td>
</tr>
<tr>
<td>Flexible landing sites</td>
<td>No (airstrip required)</td>
<td>Yes (can land at scene)</td>
</tr>
<tr>
<td>Useful for physical rescue (e.g. winch)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Secondary transfer required</td>
<td>Yes</td>
<td>Possibly but point-to-point transfers are possible</td>
</tr>
<tr>
<td>Weather affected</td>
<td>Minimal (can fly above weather)</td>
<td>More frequently affected</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High temperature reduces range</td>
</tr>
<tr>
<td>Vibration</td>
<td>Subtle</td>
<td>Marked</td>
</tr>
<tr>
<td>Noise</td>
<td>Subtle</td>
<td>Marked</td>
</tr>
<tr>
<td>Ability to work in cabin</td>
<td>Difficult but possible</td>
<td>Extremely limited</td>
</tr>
<tr>
<td>Turbulence</td>
<td>Can be significant</td>
<td>Rare</td>
</tr>
</tbody>
</table>
24.3 Based on the available information, the ideal platform in this scenario is fixed wing. The distance to cover is quite long for a helicopter and refuel stops are likely. In addition, the airplane will be able to fly above the poor weather. Finally, the working conditions in the airplane cabin will be considerably better than in a helicopter cabin.

**Keypoints**

- Different retrieval platforms offer different patient benefits.
- All available retrieval platforms should be considered by the PHR team and the tasking agency.
- Consider the relative risks to patients and crew members during retrieval and act to reduce their impact.

**Additional reading**


SECTION C

Service development and special circumstances
Incident

You are an ‘off-duty’ pre-hospital and retrieval doctor travelling with your family on an international flight when you notice a commotion in the seat just ahead of you. Two passengers are attending to a fellow passenger.

Shortly afterwards, a request is made over the public announcements system for a doctor.

Questions

46.1 What are the issues associated with offering assistance?

A 56-year-old gentleman in economy class is complaining of central chest pain. He has known ischaemic heart disease and has had a previous myocardial infarction. He is clammy and pale and has vomited once. The aircraft is 9 hours into a 13-hour flight.

46.2 Describe your initial actions.

46.3 What equipment can you expect to find on board?

46.4 Describe your management plan and further course of action.
Discussion

46.1 Personal
Many doctors feel an obligation to offer assistance in such circumstances but, for most, there is no legal requirement to do so. However, it is widely accepted that physicians do have a humanitarian requirement to offer assistance in an emergency to the best of their ability. As a PHR doctor, the unexpected in the resource poor-environment is not unusual and most are likely to offer assistance. It is important that the doctor offers to help or is invited to help rather than simply ‘taking over’ the situation. As in all aeromedical situations, the pilot is in overall control of aircraft movements and safety.

Legal aspects
Offering assistance in such circumstances is infrequent and industry experts calculate that a doctor may encounter such an emergency only once or twice in a lifetime. In addition, they estimate that the chance of litigation is close to zero. However, this is a complex area and there is no guarantee of indemnity. Legal issues will also vary considerably from country to country. It is best to state at the outset that you are volunteering for this role and that, although you have pre-hospital experience, you do not have any of your equipment with you and that you will do your best for the patient considering the situation, the environment and the equipment.

Alcohol
Having taken an alcoholic beverage does not preclude the doctor from assisting. However, the doctor should take into consideration how much alcohol they have consumed and make this clear to the cabin crew and patient before becoming involved in patient care.

Other doctors
It is possible that other doctors are on the same flight and it is worthwhile for the available clinicians to decide among themselves who is most appropriate to lead the care. Factors such as specialty, alcohol or drug consumption and fatigue should be considered. Other clinicians may be better placed to assist the lead clinician with specific roles or advice.

46.2 ABC
A brief assessment of the patient’s vital signs is required. It should be possible to assess the severity of the situation within a few minutes. Record your findings.

Crew communication
The cabin crew will be looking to you for a plan and you should voice clearly and concisely your concerns. Avoid hesitancy, mumbling and medical jargon. The space constraints in economy class are marked and an immediate request to move the patient is appropriate. More space and an ability to lie the patient flat makes first or business class ideal but there may be better 360 degree access in the galley area. However, it may be easier to move other passengers to make room rather than moving the casualty. If there are other medical personnel (e.g. nurses or paramedics) on board then try to create the ‘two-person team’ with which you are familiar. Alternatively, utilise a member of the cabin crew. Ask for all the medical equipment to be brought to your new location.
There is a wide variation in medical equipment carried by passenger airlines. The Aerospace Medical Association has a regularly updated list offering guidance in this area. The box below shows the 2007 recommendations for this kit list.

Some aircraft have access to advanced monitoring devices, which can monitor heart rate, blood pressure, oxygen saturations and even 12-lead electrocardiograms. Certain monitors allow the information to be transmitted to a dedicated medical team on the ground (e.g. MedLink). Other aircraft will have an automatic external defibrillator (AED) device on board, which will allow cardiac monitoring and defibrillation.

### Recommendations for kit list (Aerospace Medical Association, 2007)

<table>
<thead>
<tr>
<th>Drugs</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrenaline</td>
<td>Stethoscope</td>
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<tr>
<td>Antihistamine</td>
<td>Sphygomanometer</td>
</tr>
<tr>
<td>Dextrose</td>
<td>Oropharyngealairw ay</td>
</tr>
<tr>
<td>Glyceryltrinitrate</td>
<td>Syringes</td>
</tr>
<tr>
<td>Analgesic</td>
<td>Needles</td>
</tr>
<tr>
<td>Sedativeanticonvulsant</td>
<td>Intravenouscatheters</td>
</tr>
<tr>
<td>Anti-emetic</td>
<td>Antisepticw ipes</td>
</tr>
<tr>
<td>Bronchodilator</td>
<td>Gloves</td>
</tr>
<tr>
<td>Atropine</td>
<td>Sharpsdis posalbox</td>
</tr>
<tr>
<td>Steroid</td>
<td>Urinarycatheter</td>
</tr>
<tr>
<td>Diuretic</td>
<td>Fluid-givings et</td>
</tr>
<tr>
<td>Drugforpost-partumbleeding</td>
<td>Venoustourniquet</td>
</tr>
<tr>
<td>Saline</td>
<td>Gauze</td>
</tr>
<tr>
<td>Aspirin</td>
<td>Adhesivetape</td>
</tr>
<tr>
<td>β-blocker</td>
<td>Surgicalmas k</td>
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<td></td>
<td>Torchandbatte ries</td>
</tr>
<tr>
<td></td>
<td>Thermometer</td>
</tr>
<tr>
<td></td>
<td>Trachealcatheter</td>
</tr>
<tr>
<td></td>
<td>Umbilicalcordclamp</td>
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<tr>
<td></td>
<td>Basiclife support cars</td>
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<td>Bagv alvemas k</td>
</tr>
<tr>
<td></td>
<td>Advancedlife support cars</td>
</tr>
</tbody>
</table>

From the history and symptoms, acute coronary syndrome (ACS) is the most likely diagnosis but the list of differential diagnoses is extensive. The ability to perform a 12-lead electrocardiogram will be of diagnostic benefit in this regard. Supplemental oxygen is important in the aircraft cabin (see Case 24 and Case 49). There is not an unlimited supply of oxygen on the aircraft and low-flow oxygen should be used if possible to preserve supplies. Oxygen concentrators are infrequently available. Other treatments should follow in-hospital emergency guidance for ACS and include aspirin, glyceryl trinitrate and analgesia. Do not forget to discuss treatment with the pilot, the crew, the patient and his relatives (if present).
Advanced communication

Continued discussions with the cabin crew are essential throughout the incident. At some point, the doctor should speak directly to the pilot or first officer and it is likely one of them will already have approached the doctor. The pilot and the doctor should broach the subject of the aircraft diverting and what options are available. The final decision on diverting lies with the captain but he/she may rely heavily on the medical report. Note also that diverting may not be in the patient’s best interest depending on the current location of the aircraft. It will be of greater benefit to the patient to have initial treatment in flight and arrive a few hours later in a country with advanced healthcare facilities than to be diverted urgently to a country with a less robust healthcare system and then left there. There are also cost and safety issues that will arise with diverting and the decision requires thought and discussion.

The airline may have access to a telemedicine arrangement (including the telemetry-enabled monitors as described earlier) in which case the treating doctor will have the ability to discuss the case with a ground-based medical team. If available, this should be utilised not only as a valuable second opinion but also as an additional layer of medico-legal protection. This facility will also be of help with decisions regarding the need to divert the aircraft.

Documentation

The doctor should keep contemporaneous notes of the incident, particularly of key medical decisions. This is useful in the unlikely event of medico-legal issues arising but is also good practice.

Landing and handover

Most incidents on commercial aircraft do not require a change to the flight plan and it is likely the aircraft will continue to its destination. Unless there is complete resolution of the problem, the doctor should request to stay with the patient for the remainder of the flight. This is certainly the case in this scenario. Ensure that the pilot has radioed ahead to notify the receiving airport of the medical emergency. Request an appropriately staffed land ambulance to meet the aircraft, preferably on the tarmac. Unless the situation deteriorates significantly, try to allow the other passengers off the aircraft first and consider using a wheelchair to facilitate extrication (see Case 49). Do not leave the patient until he is handed over to the ground ambulance team. If time allows, try to provide a written summary of your actions for the land ambulance team as well as one for the captain.

Keypoints

- Doctors have an ethical duty to provide assistance in an emergency.
- Airline medical equipment is variable but monitoring and communication equipment is becoming increasingly sophisticated.
- Regular updating of the air crew is good CRM and will allow an unfamiliar group to function as a team.
Additional reading

Incident
You have been asked to oversee medical and major incident cover at a music concert in a large capital city. The organisers expect 50,000 people to attend.

Questions
47.1 How will you plan for the event? [Present a broad outline for managing mass-gathering events focusing on a venue such as that in the picture.]
47.2 What are your priorities on the day?

Discussion
47.1 For mass-gathering and event medicine, preparation and planning is key and should begin well before the event.

Safety
Safety is the number one priority and most plans are put in place to protect the emergency services personnel as well as the crowd.
The venue
Accurate information about the venue is essential and, ideally, the clinician should visit the location in advance. Considerations that should be addressed include:

- Geographical location.
- Nearby hospitals and available medical specialties.
- Open-air or closed venue?
- Seated, standing or both?
- Access and egress to all locations within the venue.
- Access and egress to local hospitals and estimated time frames.
- Local and national guidelines for stadiums and events.

The population
- There is a reasonable estimate of the number of persons attending based on ticket sales but for free events such as street parades there is no accurate way of predicting attendance.
- The nature of the event will define certain aspects of the population attending. This event, being a music concert, suggests a young crowd with a high risk of alcohol and drug use. It is very likely that alcohol will be available in the venue, albeit with certain restrictions.

The medical team
- This is an event requiring several medical personnel and, as lead clinician, you must establish what medical personnel are available.
- National guidelines may dictate how many physicians are required at such an event but there are rarely guidelines as to the training and experience of such doctors. In some situations, you may be the only doctor.
- The venue may have a medical centre, which can resemble a hospital or clinic but the environment outside the medical centre will also need medical cover.
- The lead clinician must have experience in pre-hospital and retrieval, event medicine and major incident management. If other physicians are available, they should also ideally have experience in one or more of these fields. There will also be nurses, paramedics and volunteer first-aiders available. A suggested approach is as follows:
  - The medical centre forms the nucleus of medical care for the venue and the plan should be that all seriously ill or injured patients should be taken there for advanced management. All retrievals to local hospitals should occur from this clinic, which should have rapid trolley access to outside the venue where ambulances are parked.
  - Satellite centres should be strategically positioned around the venue and should be staffed by a physician and nurse/paramedic team. Patients can either walk in to these locations or be brought in.
  - Mobile medical teams should move around the venue with equipment and a foldable stretcher. The team should comprise at least a nurse/paramedic but should always include two persons as a minimum. Physicians can join the team to bring advanced skills and equipment if needed. It should be feasible for a defibrillator, if required, to reach any part of the venue within 5 minutes.
Medical ‘snatch’ squads in high-risk areas are appropriate for certain events. At some music concerts, crowd surges towards the stage are common and people occasionally need extrication from the crowd at this point. Safety issues must be highlighted to the snatch teams.

A full major incident plan has to be in place before the event and major incident roles should be allocated and fully explained before the venue opens. Some personnel may have dual roles (i.e. treating of routine patients unless a major incident occurs) but be aware that medical personnel with dual roles run the risk of being drawn into prolonged patient care and, therefore, may be unable to respond rapidly in the event of a major incident. Certainly the lead clinician should avoid patient contact if at all possible.

Medical equipment will be available on site but a breakdown of the kit and its location should be studied in advance. There will always be limitations on available kit and efforts should be made to work with what is available. Remember what is available this is unlikely to be the first event catered for at this location and other members of the team may be familiar with the kit. If you feel there is anything crucial missing then it can be requested in advance from the organisers or brought as personal equipment.

**Inter-service liaison**

This is a multidisciplinary arrangement and will not be functional without close liaison between the emergency services:

- Overall, the police are in command and the lead clinician should link up with the Police Service commander and, likewise, with the Fire & Rescue Service commander. Both these services have responsibilities for public safety and medical personnel must be aware of their plans.
- Some mass gathering venues have coded warnings to alert members of the emergency services to a potential major incident without generating panic in the crowd. Make sure you know these warnings, which will usually be broadcast over the public address system and will sound very benign (e.g. ‘Will the stadium manager please report to Gate A’ could be the coded warning for a credible bomb threat).
- Local ambulance control should already be aware of the event and will have their own plans in place for hospital transfers and major incidents. These should conform to national guidelines. Speak to the Ambulance Service commander and run through medical evacuations, number of ambulances available and major incident roles. Make sure ambulance control have made plans with the police for traffic flow in the event of an evacuation to hospital. This can be particularly difficult in the hours after the event when the roads are full of people exiting the venue. There should also be a plan for persons calling for an ambulance from inside the venue on mobile phones whereby details and location are forwarded to the mobile medical teams.
- Local voluntary organisations (e.g. the Red Cross) or paid medical companies are often the core providers of healthcare in mass-gathering events. Make sure that contact is made with the commander of these organisations early on. All plans, including major incident plans, should be discussed with this provider.

47.2 Check weather reports a few days in advance as this will help with planning. Clothing should be practical but protective and you should receive appropriately labelled reflective tabards at the venue. Arrive early on the day and obtain your security pass.
Walk through as much of the location as possible, noting exits and choke points (e.g. the stairwells). Visit the control room (all venues will have a central command position) and introduce yourself to the people inside. There is likely to be an impressive array of closed circuit television and this can help to generate a mental image of the location. In addition, these cameras can be the first to spot a casualty in the crowd and your mobile medical teams may be directed to the site by the camera operators. 

Make sure local hospitals are aware of the event and the potential of extra work especially after the event. Visit the medical centre, introduce yourself to the medical personnel and check the equipment. For large events, many of the above tasks should be done in the days prior to the event to maximise efficiency. 

Communications at such events are usually excellent and each team should have a radio and a call sign as well as a back-up mobile phone. Run through radio etiquette before the event to make sure everyone is familiar with procedures. Stress the importance of describing a location accurately. Labelled miniature maps of the location utilising grid reference systems may be of help. 

A briefing of all medical and voluntary services personnel should occur before any member of the public enters the venue and the chain of medical command must be highlighted. Medical staff must be aware of the importance of documenting all patient contacts and a standardised patient documentation form should be provided. 

Finally, make sure medical staff are not distracted by the event itself or by the celebrity performers. Many performers provide their own medical cover (personal doctor etc.) and this should be established early on. In the absence of personal medical cover for the performers, a specific ‘backstage’ team needs to be formulated. As lead clinician, do not disappear backstage as this will leave the remainder of the venue ‘uncovered’.

**After the event**

Thank all the staff and emergency personnel whether they were busy or not. 

Provide feedback to the organisers regarding things that went well during the day as well as offering suggestions for improvement. A full written report including a critical appraisal of the event is ideal. Offering to help at any future training events held at that and other locations will improve crew resource management.

**Key points**

- Careful planning in the days and hours before the event will improve clinical risk management. 
- The lead clinician should not be involved in direct patient care.