

Guidelines

AAGBI: Safer pre-hospital anaesthesia 2017

Association of Anaesthetists of Great Britain and Ireland

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Summary

Pre-hospital emergency anaesthesia with oral tracheal intubation is the technique of choice for trauma patients who cannot maintain their airway or achieve adequate ventilation. It should be carried out as soon as safely possible, and performed to the same standards as in-hospital emergency anaesthesia. It should only be conducted within organisations with comprehensive clinical governance arrangements. Techniques should be straightforward, reproducible, as simple as possible and supported by the use of checklists. Monitoring and equipment should meet in-hospital anaesthesia standards. Practitioners need to be competent in the provision of in-hospital emergency anaesthesia and have supervised pre-hospital experience before carrying out pre-hospital emergency anaesthesia. Training programmes allowing the safe delivery of pre-hospital emergency anaesthesia by non-physicians do not currently exist in the UK. Where pre-hospital emergency anaesthesia skills are not available, oxygenation and ventilation should be maintained with the use of second-generation supraglottic airways in patients without airway reflexes, or basic airway manoeuvres and basic airway adjuncts in patients with intact airway reflexes.

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- *What other guideline statements are available on this topic?*

The Association of Anaesthetists of Great Britain and Ireland (AAGBI) first produced guidelines on this area of practice in 2009 [1]. Other related guidelines have been produced in Scandinavia [2] and in the USA [3].

- *Why were these guidelines developed?*

The guidelines were first developed because pre-hospital anaesthesia is carried out on a daily basis in the UK, and standards of care were ill defined. They set achievable standards which were endorsed by key organisations. This version updates these guidelines, taking into account changes in clinical practice, pre-hospital infrastructure and new related guidelines that have impacted on the practice of pre-hospital anaesthesia.

- *How and why does this statement differ from existing guidelines?*

This updated guideline emphasises the core material produced in the initial guideline, but is updated to reflect changes in UK pre-hospital infrastructure and recent guidelines on airway management, trauma management and emergency in-hospital anaesthesia and monitoring. There are significant differences to Scandinavian and US guidelines, mostly related to differences in emergency medical services (EMS) infrastructure and providers.

Introduction

There are existing local and national guidelines for pre-hospital emergency anaesthesia (PHEA) and airway management [2, 4]. Since the first version of these UK guidelines was produced [1], significant developments have taken place in UK pre-hospital care. The number of air ambulances staffed with doctor–paramedic teams in the UK has increased, and with this the frequency of PHEA. Pre-hospital emergency medicine (PHEM) has been recognised by the General Medical Council as a subspecialty, and pre-hospital training organisations are required to demonstrate clear evidence of a clinical governance structure.

Although the evidence base for pre-hospital care and PHEA is still of relatively low quality, much has been published recently. For example, available data on pre-hospital tracheal intubation failure rates have more than tripled, and have been used as one indicator to confirm the importance of experience and training in successful pre-hospital anaesthesia [5–7].

In 2007, the ‘Trauma: who cares?’ National Confidential Enquiry into Patient Outcome and Death (NCEPOD) report documented poor pre-hospital airway management [8]. A significant proportion of seriously injured patients were delivered to emergency departments with airway compromise, and this is not unique to the UK [9]. More recently, it has been demonstrated that, in a significant number of trauma patients, basic and advanced airway management

without PHEA does not reliably correct airway compromise [10].

The majority of severely ill and injured patients have intact airway reflexes, and require drugs to facilitate tracheal intubation. In contrast, tracheal intubation has not been shown to improve outcome in patients with cardiac arrest [11], and drugs are not usually required to facilitate tracheal intubation in this patient group.

Many UK pre-hospital services have aspired to achieve the key message of the AAGBI 2009 Pre-hospital anaesthesia guidelines – that, despite variable pre-hospital conditions, the standard of care delivered should be the same as that for in-hospital emergency anaesthesia [1]. Recent evidence has shown that anaesthesia in the Emergency Department is not without problems [12], and the standardisation of technique, along with safety adjuncts such as pre-induction checklists are probably essential in both the pre-hospital and Emergency Department environments.

This guideline outlines safety considerations in the key areas of pre-hospital anaesthetic practice: training and clinical governance; conduct and technique; monitoring; environmental considerations; and minimum data collection for performance and incident reporting. It does not consider local and regional anaesthetic techniques.

Although there are many options for the safe delivery of PHEA, the principles of simplicity and standardisation are used in this document to provide a framework for safe delivery of emergency anaesthesia by experienced pre-hospital doctors from anaesthetic or non-anaesthetic training backgrounds. It is recognised that pre-hospital practitioners without PHEA competency provide the majority of pre-hospital care in the UK, and make an essential contribution to pre-hospital airway management. It is essential that pre-hospital personnel not trained in the delivery of PHEA ensure that basic airway manoeuvres are applied immediately and effectively for any patient with airway compromise [4]. This may be facilitated by managing the patient in the lateral trauma position where appropriate [2, 13].

Local organisation

All pre-hospital organisations (immediate care schemes, hospital-related schemes, Medical Emergency Response Incident Teams (MERIT), air

ambulance providers and NHS Ambulance Service Trusts) must provide appropriate, easily accessible and ongoing support to practitioners who undertake PHEA.

Pre-hospital emergency medicine trainees undertaking PHEA without direct supervision must have immediate access to advice from a senior PHEM clinician who is fully competent in PHEA and pre-hospital critical care. Non-trainees who undertake PHEA should also ideally have reliable access to senior telephone support.

Key organisational components for safe PHEA are:

- A named, responsible lead clinician with extensive PHEM experience, who ensures delivery of competency-based initial and refresher training specific for PHEA, including: simulation practice; regular review of PHEAs undertaken and constructive feedback to individual providers; and regular appraisal of practitioners undertaking PHEA.
- A robust clinical governance structure that will: ensure each practitioner is competent; ensure collection of key data on PHEA performed to enable quality benchmarking of pre-hospital advanced airway management [14]; provide regular case reviews, audit and an adverse event reporting system feeding into a risk register database; and provide regular reviews of guidelines and standard operating procedures in the light of emerging evidence.

Pre-hospital anaesthesia for children

It is increasingly recognised that anaesthesia for children aged 8 years or under is a sub-specialist area of in-hospital anaesthesia. Young children with severe injuries are uncommon, but can present pre-hospital practitioners with significant challenges. All pre-hospital organisations must have written guidelines for the treatment of children that reflect the skills of their practitioners.

In general terms, the threshold for anaesthesia and tracheal intubation in young children is high. The majority can be adequately managed with simple airway techniques [15]. Pre-hospital emergency anaesthesia is considered only after careful risk–benefit analysis. This will usually mean that a skilled

anaesthetic practitioner with appropriate equipment is present, and that simple airway manoeuvres combined with oxygen therapy have failed to provide a patent airway or adequate oxygenation. However, where PHEA is necessary, it is usually straightforward with high intubation success rates [16].

In difficult circumstances, rapid transfer to the nearest hospital to enable advanced airway management may be appropriate, even if definitive care needs to be undertaken at a different hospital.

Personnel and training

Individual competence

Pre-hospital emergency anaesthesia carries more risk than in-hospital anaesthesia. Skilled anaesthetic assistance may not be available, and both environmental and patient factors increase risk. Pre-hospital emergency anaesthesia should not be undertaken in professional isolation. Providers should have the same level of training and competence that would enable them to perform unsupervised emergency anaesthesia and tracheal intubation in the emergency department [17, 18]. Since PHEA is potentially hazardous [12], and considerable resource is spent to ensure that anaesthetists who perform rapid sequence induction (RSI) in hospitals can do so safely, pre-hospital care standards should at least match these standards.

Some studies have demonstrated low success rates and significant complications when RSI and tracheal intubation are undertaken by individuals with relatively little training [19]. The 2007 NCEPOD ‘Trauma: Who Cares?’ report concluded that *“if pre-hospital intubation is to be part of pre-hospital trauma management, then it needs to be in the context of a physician-based pre-hospital care system”* [8].

The training required for undertaking pre-hospital anaesthesia safely and competently has been described by the Intercollegiate Board for Training in Pre-hospital Emergency Medicine (IBTPHEM) [17]. Skills in both anaesthesia and the ability to work safely in the pre-hospital environment are required. Competence should be defined by these skills, rather than by the primary specialty of the individual.

The Royal College of Anaesthetists requires that all anaesthetists in training complete an Initial Assessment of Competence before giving anaesthesia without

direct supervision. This assessment is completed by the trainee after about 3 months of anaesthesia training, and includes the ability to perform RSI and a failed intubation routine. The Initial Assessment of Competence confirms that the individual has the essential skills to undertake anaesthesia in ASA 1 or 2 patients in hospital. However, the achievement of this standard does not imply competence to induce anaesthesia in a severely injured patient in any setting.

The two-year acute care common stem (ACCS) training programme provides individuals with 6 months of training in emergency and acute medicine and a year in anaesthesia and intensive care medicine. However, doctors completing ACCS training are inexperienced in managing the airway of complex patients, and will need further training before undertaking unsupervised pre-hospital RSI and tracheal intubation.

The ACCS programme (or equivalent training) is considered the absolute minimum required for an individual entering a training programme in pre-hospital emergency medicine. Specific training for working in the pre-hospital environment is also essential. The IBTPHEM and the Faculty of Pre-Hospital Care of the Royal College of Surgeons of Edinburgh are currently the lead organisations setting standards for physician pre-hospital working, qualification and competence. Ideally, doctors likely to be undertaking PHEA should, in the future, successfully complete the IBTPHEM subspecialty training in pre-hospital emergency medicine [17].

Anaesthetic assistance should be provided by an appropriately trained healthcare professional who has been signed off for extended pre-hospital care practice, or assessed to provide specific pre-hospital critical care skills. Rarely, it may be appropriate to proceed without trained assistance on the basis of an individual case risk–benefit analysis.

Working under the close supervision of experienced practitioners is an essential step towards independent pre-hospital practice. Having achieved PHEA competence, skills need to be maintained by undertaking the procedure regularly. The precise number of PHEAs required to maintain competence is not defined. An average of one a month has been previously suggested as a minimum. There is a significant difference in the reported incidence of difficult tracheal intubation between clinicians considered either ‘competent’ or

‘expert’ (based on the number of intubations performed per year) [20]. Unless an individual is working in a very busy pre-hospital programme, it is likely that competence in RSI and tracheal intubation will be achieved only with regular in-hospital experience of RSI and tracheal intubation, supplemented with simulation experience where necessary. Assessment of competence in PHEA should always involve direct pre-hospital observation by experienced senior clinicians. Simulator practice may usefully supplement clinical experience. Practitioners undertaking PHEA must keep a log of procedures to be included in a clinical governance structure.

Crew resource management techniques are of particular importance in the pre-hospital environment, and it is critical that teams have the opportunity to train and practice regularly in order to ensure the best possible delivery of care. Pre-hospital care teams need to be adaptable to changes in their environment to ensure scene and patient safety. Appendix 1 discusses safe PHEA in challenging environments.

The Working Party is aware of variable international practice with regard to non-physician delivered drug-assisted intubation. Although non-physician delivered PHEA is relatively uncommon, the administration of sedation to facilitate intubation is reported in some healthcare systems. Working Party members are aware of published evidence that has highlighted major safety concerns, particularly where non-physicians have administered neuromuscular blocking drugs [21, 22], and do not believe that existing training programmes enable safe unsupervised administration of anaesthesia by non-physicians outside physician-led teams in the UK. A similar position is stated in recent NICE trauma guidelines [4].

The Working Party believes that all practitioners providing PHEA should have adequate in-hospital emergency anaesthetic training and experience, and be able to demonstrate the necessary competencies before adapting in-hospital practice for pre-hospital practice.

Equipment and monitoring

Standards of equipment and monitoring used for PHEA should match those applied to in-hospital anaesthetic practice [23]. To prevent cross-infection, most pre-hospital providers have to use ambulance or hospital sterilisation facilities, or rely on disposable equipment.

Equipment

Pre-hospital equipment must be portable, robust and weather-resistant, and be effective under varying lighting conditions. Electrical equipment must have an adequate battery reserve. Equipment for very adverse conditions (e.g. extreme temperature environments) needs careful selection and confirmation of suitability before use.

The equipment required for pre-hospital anaesthesia is shown in Table 1.

Monitoring

Clinical assessment, combined with monitoring, is used to record the patient’s condition from the preparation phase, through induction and maintenance, and into the postintubation and transfer phase. Measured values can be recorded manually or electronically during the whole period, although it is recognised that manual recording is difficult in the emergency setting.

Clinical measurement and observation should include: the presence or absence of a pulse, its location and rate; respiratory rate; pupil size and reactivity, lacrimation if present; and the presence or absence of muscular activity and limb movements.

Invasive monitoring is possible, but can be difficult in the pre-hospital phase, and is mainly used for inter-hospital transfer. Non-invasive monitoring includes, as a minimum: heart rate; non-invasive blood pressure;

Table 1 Equipment for pre-hospital emergency anaesthesia (PHEA).

Monitoring equipment
Oxygen (sufficient for PHEA and transfer to hospital, with reserve)
An adequate supply of drugs (ideally pre-prepared and drawn up into labelled syringes) for induction and maintenance of anaesthesia.
Intubation equipment, to include an intubating bougie and spare laryngoscope
Simple airway adjuncts:
Suction: hand or battery operated;
Ventilation equipment: self-inflating bag-mask with an oxygen reservoir (as a minimum);
Mechanical ventilators: properly serviced and checked with appropriate pressure relief systems and alarms;
Rescue airway equipment: second generation supraglottic airway device and surgical airway equipment.
Vascular access equipment: intravenous and intra-osseous
Lighting where appropriate
Procedural checklists

oxygen saturation; continuous waveform capnography; and electrocardiography [23].

Vital signs should be measured and recorded at least every 3 min. As oxygen or an oxygen–air mix are the only commonly used gases during PHEA, anaesthetic gas monitoring is rarely used in the pre-hospital environment. Gas supply failure alarms should be present on mechanical ventilators. Nerve stimulation devices are also rarely used in the pre-hospital environment. With these exceptions, monitoring in the pre-hospital environment should aim to meet the current AAGBI guidelines on anaesthetic monitoring [23]. Monitoring of end-tidal CO₂ is mandatory during PHEA. Although qualitative capnography can be used to help confirm intubation, quantitative waveform capnography is required to prevent hyper- or hypoventilation. It is important to ensure that the circuit and equipment is connected and functional before induction. Temperature monitoring should be considered particularly for vulnerable patient groups (e.g. children or those with significant burns).

Audiovisual alarms on monitoring equipment should be set so that they can be detected in the noisy pre-hospital environment. Monitoring may need to be temporarily suspended during difficult extrication. Appendix 2 discusses minimum data collection and key performance indicators.

Technique (general principles)

The principles of PHEA are similar to those for in-hospital emergency anaesthesia. Techniques should be simple, reproducible and well-practised. A primary aim is to secure first-pass tracheal intubation with minimal cardiorespiratory compromise. The most commonly used induction drugs and neuromuscular blocking drugs can be used in pre-hospital care with appropriate considerations. Drug choice depends on the physiological state of the patient, and operator familiarity with the drug.

The balance between optimising clinical condition before transfer and getting the patient to definitive care without delay will determine which interventions are undertaken before transport to hospital. Although PHEA increases ‘scene time’, time in the Emergency Department and time to definitive surgical intervention may still be reduced. Performing the intervention must

still be weighed against the advantages of earlier transport to hospital, and every effort must be made to keep pre-hospital time to a minimum.

Preparation

Careful preparation of the patient and equipment will decrease the frequency of complications. The patient should ideally be positioned to allow 360° access at a comfortable height for airway intervention (e.g. on an ambulance trolley), in adequate but not bright light, to optimise the view at intubation.

A standardised ‘kit dump’ is prepared so that the drugs and equipment necessary for safe anaesthesia are immediately available. The pre-hospital team should be thoroughly familiar with all medical equipment. A verbal challenge–response pre-induction checklist is an effective method of confirming availability of equipment, doses of drugs to be administered and the failed intubation management plan.

The pre-hospital team should be fully briefed. Ideally, four people are required: PHEA physician; anaesthetic assistant; provider of manual in-line stabilisation; and provider of cricoid pressure and/or laryngeal manipulation (sometimes combined with role two).

Genuine entrapment is rare, and most trapped patients can be rapidly extricated to facilitate airway management. Simple airway manoeuvres and adjuncts may be used to avoid airway obstruction before rapid extrication. If these measures fail, insertion of a supra-glottic device, tracheal intubation or a primary surgical airway may be necessary.

Pre-oxygenation

All patients should be pre-oxygenated. A head-elevated position can improve oxygenation and reduce the risk of aspiration. A reverse Trendelenburg position can be used if spinal injury is suspected.

Pre-oxygenation in spontaneously breathing patients may be achieved using high-flow oxygen delivered through a facemask with a reservoir bag. Hypoxaemic patients (SaO₂ < 90%) or patients with poor respiratory effort usually require gentle support of ventilation with a bag-mask to facilitate pre-oxygenation. The risk of gastric distension and subsequent aspiration can be reduced if ventilation pressures are kept at less than 25 cmH₂O [24].

The provision of apnoeic oxygenation with oxygen via standard nasal cannulae may, where the airway is patent, may prolong the time to postinduction desaturation. Although this intervention has been demonstrated to decrease the incidence of desaturation in PHEA [25], the evidence base for these techniques is currently limited [26–30].

Induction

Hard collars limit jaw opening and restrict the view at laryngoscopy. Once manual in-line stabilisation is established, the front of the collar and head blocks should be removed before induction of anaesthesia, and replaced after induction.

The dose of induction drug should be selected based on the usual considerations, for example, modified for hypotensive or head-injured patients. Simple techniques should minimise the risk of error.

Cricoid pressure should be applied during induction of anaesthesia to reduce the risk of aspiration. This may make bag-mask ventilation and insertion of supraglottic devices difficult, and may improve or worsen the view at laryngoscopy [30, 31]. If it is difficult to view the larynx, there should be a low threshold for removal of cricoid pressure. However, cricoid pressure may also be used to facilitate laryngeal manipulation to improve the view for the operator.

Intubation

Patients with airway compromise in the pre-hospital environment may be challenging, and difficult intubation should be anticipated. Every effort should be made to ensure successful first-pass intubation, and in critically ill patients, the practitioner with most anaesthetic experience should usually be the first to attempt intubation. Routine use of an intubating bougie is recommended. Pre-hospital organisations may approve other 'difficult airway' equipment at a local level.

The number of tracheal intubation attempts is limited to three [30], and, where possible, the conditions for successful intubation should be improved between each attempt. If a patient becomes hypoxaemic during intubation attempts, the lungs should be ventilated via a facemask or a supraglottic device. Articulating the nature of a problem to the anaesthetic assistant may improve team performance and enhance patient safety.

All pre-hospital organisations must have written and well-rehearsed 'failed intubation' plans. These should include the use of a second-generation supraglottic airway rescue device, and clear indications/instructions for performing surgical cricothyroidotomy. Standard, easily reproducible techniques are described in the 2015 Difficult Airway Society guidelines [30]. It is unclear if there is any role for needle cricothyroidotomy. It is associated with high rates of complication and failure, and always requires conversion to standard surgical cricothyroidotomy [32, 33].

Correct tracheal tube placement must be confirmed by standard clinical assessment and waveform capnography, and should be repeated each time the patient is moved. The breathing system (self-inflating bag or portable ventilator) should be connected using an in-line heat and moisture exchange filter.

After confirmation of correct placement, the tracheal tube must be secured. A circumferential tie around the neck may impair venous drainage of the head and neck, and it is preferable to use self-adhesive tape for head-injured patients.

Post-intubation care

Wherever possible, practical procedures should be completed before patient transport, as they are more difficult to perform safely once transfer is underway. The patient should be prepared for transfer by ensuring that intravenous cannulae and adequate oxygen supplies are accessible. Although high-flow oxygen therapy is routine practiced in trauma care, it is sometimes necessary to use lower flows for stable patients, titrated against oxygen saturations to conserve supplies during transfer.

Where possible, post-intubation critical care should commence in the pre-hospital phase of care. Lung-protective ventilation strategies should be used, but reduction or removal of positive end-expiratory pressure may be necessary in hypovolaemic patients. Ventilation is adjusted to achieve normocapnia, equivalent to an end-tidal CO₂ of 4.0–4.5 kPa. The correlation between arterial and end-tidal CO₂ may be reduced in patients with significant physiological or anatomical derangement. Abnormal end-tidal CO₂ is associated with increased mortality [34]. The use of transport ventilators (rather than continued hand

ventilation) may decrease the risk of hyperventilation, and free up a member of the pre-hospital team [35].

In most patients, a hypnotic drug (e.g. midazolam or propofol) will be required to maintain sedation during transfer. Accidental anaesthetic awareness is more likely whenever neuromuscular blocking drugs are used, particularly in emergency patients with high pre-induction Glasgow coma scores [36]. Small, frequent doses of sedatives minimise haemodynamic side-effects, and should be titrated against physiological variables. Infusions may be preferable for longer transfers, but infusion pumps may make transfer more complex.

Historically, there have been concerns about using ketamine in patients with head injury because of the risks of increased intracranial pressure. These concerns are of little practical significance, and the drug is now frequently used in PHEA in patients with head injury [37, 38]. Relative haemodynamic stability makes ketamine an attractive induction drug for pre-hospital trauma care, but the sympathomimetic effects may have disadvantages where anaesthesia is delivered after resuscitation from cardiac arrest or in patients with severe cardiac disease.

Pre-anaesthesia sedation

Background

Sedation remains a cause of significant morbidity and mortality, despite the recent publication of comprehensive guidelines that advocate knowledge, skills and a competency-assessed framework for all clinicians using sedation. Patients requiring PHEA are frequently critically unwell and susceptible to the complications of sedation. This guideline considers sedation practice only in association with PHEA, but notes that practitioners undertaking pre-hospital sedation should be trained to the same standards as those developed for safe in-hospital practice [39], and must also have the requisite skills to deal with potential life-threatening complications. Working Party members are aware of recent discussions related to sedation to allow insertion of supraglottic devices for airway management where PHEA skills are not available. There is no evidence base to support this practice, and the safety and potential benefits of this procedure are not established.

Potential benefits

Patients who require PHEA may be confused, agitated or even combative [40]. Underlying anxiety, pain and hypoxia can be exacerbated by failure to comply with simple treatments such as oxygen administration, so that pre-oxygenation before PHEA may be ineffective. Judicious use of sedation can facilitate the establishment of monitoring and ensure adequate pre-oxygenation.

Physical restraint may be required to prevent patients from harming themselves or others. Restraint may precipitate a rise in blood pressure or intracranial pressure, threaten undiagnosed spinal injury, disturb clot formation and promote bleeding [41]. Using a physical restraint may also impair performance of the clinical team. In contrast, provision of anxiolysis and sedation may improve the ability of the operator to deal with other elements of patient care or scene management.

Potential disadvantages

In critically unwell patients, the speed of onset and effect of sedatives may be significantly altered, and a reduced dose may be required. Excessive sedation may cause hypoxia, hypercapnia and hypotension through loss of the airway, depression of ventilation and vasodilatation.

Principles of sedation before rapid sequence induction

Employment of non-pharmacological methods to reduce anxiety and agitation should be considered. The patient should not be crowded, and a 'single face' point of contact for the patient should be used. A target level of sedation should be aimed for [39]. The patient should be quiet, but responsive to verbal or painful stimuli. High-risk patients should be identified; those who are frail, elderly, critically ill or have concomitant use of other drugs, for example, opioids [42]. Dilution of the sedative helps to provide better control of the dose administered. For sedation, the intravenous route should be used in preference to intramuscular or other routes [39]. Titration of small doses of sedation are carried out to achieve the desired effect [43] (e.g. 1–2 mg increments of midazolam). In frail, elderly, haemodynamically unstable patients, even-smaller

increments can be considered. End-tidal CO₂ monitoring must be used for all patients undergoing moderate or deep sedation [39].

When to consider intramuscular sedation

Where intravascular access is difficult (e.g. in combat-ive patients or those with a history of intravenous drug abuse), it may be necessary to sedate the patient using the intramuscular route [43]. As titration is not possible, a drug such as ketamine that will not cause respiratory or cardiovascular collapse should be used. Once the patient is sedated, peripheral, central or intra-oss-eous access can be established before proceeding with anaesthesia. Oral sedation may also be considered in some circumstances. The intranasal route has also been used successfully for pre-hospital sedation and analgesia, particularly in children.

Transport

Following induction of anaesthesia, the patient should, in most circumstances, be transported directly to an appropriate hospital [4]. Secondary transfer can be detrimental to patient outcome, particularly in time-critical injuries [44]. Standards of care initiated at induction of anaesthesia must be continued during transport, including: continuous monitoring of vital signs – ECG, blood pressure, pulse oximetry and wave-form capnography; maintenance of anaesthesia – adequate sedation, analgesia and, if necessary, neuromuscular blockade; and the provision of support-ing equipment – airway suction, intubation equipment, intravenous fluids; contemporaneous written or auto-matically generated records of vital signs and treat-ment interventions.

The transport process (availability and type of vehicle, distance and time to definitive care, journey and terrain) should be carefully considered before undertaking pre-hospital anaesthesia. The transport vehicle must be suitable for the safe transfer of the anaesthetised patient and attending team. A fixed patient-carrying device should be used, with straps to keep the patient secure during transit. To ensure the safety of personnel, all equipment should be secured, and the transporting team should remain seated and restrained. Transport vehicles must comply with road

safety or air transport regulations, and be driven/pi-loted by a trained person experienced in patient trans-port. Pre-hospital personnel who perform aeromedical transfer must have undertaken specific training [45].

The receiving hospital must be given sufficient warning of the patient's arrival, and the transferring clinician is responsible for patient handover to the receiving clinical team. The AAGBI and Intensive Care Society have published recommendations on the trans-fer of ill and injured patients [45, 46], most of which are applicable to the transportation of patients who have undergone PHEA.

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Appendix 1

Safe anaesthesia in challenging environments

The practice of PHEA in genuinely dangerous or extreme environments carries additional risks that must be considered in the planning and delivery of care. Such environments may include: areas of conflict, including battlefields or civil disturbances; areas of extreme climate and/or high altitude; areas with risk of exposure to chemical, biological, radiological or nuclear (CBRN) threats; and areas that are remote or difficult to access. Constraints are usually related to access, time, threat, resource limitation and the capacity of the emergency medical services system.

General principles

The standards of care described in this guideline are applicable, even in adverse environments. Where this is not possible, careful consideration must be given as to whether the delivery of PHEA is appropriate. If not, measures to proceed safely without PHEA must be considered. This includes the planning of remote expeditions, where the medical support, drugs and equipment required to perform PHEA safely is only available in exceptional circumstances.

Personal protective equipment

Consideration must be given to the safety of the pre-hospital team and their patients. Suitable personal protective equipment is essential for all involved, but

practitioners need to be aware that equipment such as body armour can make standard techniques difficult. This is especially the case in the CBRN environment, where the conduct of conventional anaesthesia is often impossible. Biological hazards may preclude the use of high-level interventions, even when they are available. Threats to practitioners and equipment may outweigh the potential benefits of PHEA.

Scene safety

The casualty should be moved to the safest available location before any intervention. In general, the threat of remaining exposed to assault, extremes of temperature or other highly adverse conditions is likely to outweigh the risk of delaying PHEA.

Threats can develop rapidly in adverse environments, and practitioners must understand that their situational awareness will be significantly impaired when concentrating on PHEA or other complex interventions. Other team members should monitor and maintain scene safety.

Competence and training

In addition to the general competency requirements associated with PHEA, practitioners working in adverse environments should ideally undertake additional training specific to the area of their work (e.g. mountain medicine, tropical medicine or combat casualty care).

Appendix 2

Minimum data collection and key performance indicators

Minimum data collection

Pre-hospital emergency anaesthesia is increasingly practised, and yet remains supported by few data. The data are heterogeneous, making it difficult to draw meaningful conclusions. Advanced airway management in pre-hospital care has been identified by an expert panel as a research priority [47], and consensus-derived datasets need to be developed [14, 48]. Adequate data collection is essential to underpin local audit and clinical governance processes.

The following variables have been suggested as part of the minimum dataset:

- System variables: highest level of emergency medical service provider on scene; airway equipment available; anaesthetic drugs available; methods of transportation; and response times.
- Patient variables: age; sex; comorbidities; estimated weight; presenting illness/injury; and indication for airway intervention.
- Intervention variables: vital signs pre- and postinduction of anaesthesia; drugs (and doses) used; number of intubation attempts; intubation success; management of failed intubation; devices used in successful airway management; and adverse events including hypoxia, hypotension, arrhythmias (bradycardia), aspiration, misplaced tracheal tube, oesophageal intubation (recognised/unrecognised), cardiac arrest.
- Structure/system: routine use of a standard operating procedure and checklist for PHEA; all team members familiar with the failed intubation plan; daily equipment checks performed; and full monitoring, including continuous waveform capnography available.
- Process: pre-oxygenation performed for 3 min; intubation performed by experienced airway provider; no decrease of more than 20% in systolic blood pressure; no decrease in SaO₂ < 90%, or fall of > 10% from starting value; and no more than two attempts required for intubation.
- Outcome: position of tracheal tube maintained and confirmed using waveform capnography; adequate anaesthesia maintained during transfer; cardiovascular stability maintained; ventilation titrated to end-tidal CO₂.

Key performance indicators

Measuring quality in PHEM can be challenging. The categorisation of key performance indicators (KPI) has been previously described [49], and might be helpful in defining KPIs for PHEA. Examples are shown below.

The exact content of the data set and KPIs may be adapted to specific systems and their governance projects.