GREAT NORTH AIR AMBULANCE

PREHOSPITAL EMERGENCY ANAESTHESIA (PHEA)

COURSE MANUAL 2023

Prehospital Emergency Anaesthesia Course
Course Manual

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CHAPTER ONE

INDICATIONS AND DECISION-MAKING

Prehospital emergency anaesthesia (PHEA) refers to the induction of anaesthesia and securing of the airway in the prehospital environment. It is a modified form of rapid sequence induction (RSI) and intubation.

It is important to recognise that PHEA is a high-risk intervention that is performed in a sub-optimal environment on a patient that is most likely very ill or injured. Historically, a general anaesthetic was performed once the patient got to hospital, however with an increased presence of prehospital doctors, it was realised that this critical intervention could be brought forward. PHEA is one element of prehospital critical care, which has been advocated for in NICE guidelines on Major Trauma (NICE, 2016) and there is evidence of improved outcomes for patients.

In 2007, the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) released a review titled, *'Trauma: Who Cares?'*. Recommendations from this report include:

> *"Airway management in trauma patients is often challenging. The prehospital response for these patients should include someone with the skill to secure the airway, (including the use of rapid sequence intubation), and maintain adequate ventilation."*
>
> *"There is a high incidence of failed intubation and a high incidence of patients arriving at hospital with a partially or completely obstructed airway. Change is urgently required to provide a system that reliably provides a good airway with good oxygenation and control of ventilation. This may be through the provision of personnel with the ability to provide anaesthesia and intubation in the prehospital phase or the use of alternative airway devices."*

These recommendations led to a nationwide review of how prehospital providers were delivering airway care to their patients. It also recognised that general anaesthesia and rapid sequence induction is viable in the prehospital setting. This has led to many services adopting the use of specially trained teams that are capable of safely fulfilling this need.

The Association of Anaesthetists released a safety guideline in February 2009 covering Prehospital Anaesthesia. This paper, which was updated in 2017, outlines the necessary requirements for the delivery of safe PHEA.

The National Institute for Clinical Excellence (NICE) issued guidance in a paper titled, 'Major trauma: assessment and initial management (2016)'. Within the guidance, it again recognises RSI as an approved practice. It states that providers should *"aim to provide an RSI as soon as possible and within 45 minutes of the initial call to the emergency services, preferably at the scene of the incident"*. The inclusion of PHEA in national guidelines recognises how, if done correctly and appropriately, it can impact positively on patient outcome.

In an observational study performed by D. Lockey et al, (2014), the success rates of intubation and failed airway rescue techniques were reviewed in 7256 attempted intubations of trauma patients by prehospital physicians. This study found the overall success rate for intubation was 99.3% with 100% success rate after rescue techniques were used. This was a significant piece of research as it showed that the procedure was safe to do in the prehospital field.

Success has come from stringent training, clear guidance on recommended techniques and rigorous appraisal and monitoring of the procedure.

The debate as to whether this is appropriate is still contested by some, but by many it is recognised as common and safe practice that is suitable to be undertaken by suitably trained practitioners in the prehospital environment. Some will point to Losses et al. (2011), who performed a systematic literature review of PHEA and found it difficult to establish the evidence-base. The literature showed a *heterogenous* patient group with variations in the severity of illness and injury patterns. Other complications come into consideration when looking at the evidence as many prehospital variables exist depending on the environment the teamwork in. These can include:

- Urban versus rural setting: This may influence a person's threshold for PHEA.
- Helicopter versus land ambulance: Distance and travel time to the receiving hospital should also be considered.
- Doctor and/or paramedic: The staffing at different services varies.
- With or without drugs.
- Governance variation: The way organisations audit and monitor the procedure and its consequences vary.

As prehospital practice develops the evidence base is increasing however heterogeneity is likely to remain.

The following chapter aims to look at the indications and decision making that goes in to performing a safe and successful PHEA.

Aims of anaesthesia and sedation

The delivery of an anaesthetic is a huge responsibility, and we must be clear on our aims. Our first and most important aim is to avoid causing harm to our patient; *first do no harm*.

Elective anaesthesia aims to prevent awareness or recall of the surgical procedure, maintain normal physiology and to provide the patient to the surgeon in a state that facilitates the surgical procedure.

In prehospital emergency anaesthesia, we have similar but different priorities. Our patients are desperately sick before we start and it is likely that their physiological responses are doing all they can to keep them alive. We must recognise the harm we can do by over-riding that physiological response and ensure that we support the patient's physiology.

Our aims are:

1. *Keep the patient alive*
2. *Maintain adequate physiology appropriate to their illness and/or injuries*
3. *Permit interventions to manage the patient's illness and/or injuries*
4. *Reduce intracranial pressure and cerebral metabolism*
5. *Prevent awareness/recall*

There are some basic questions the practitioner should first ask themselves before the decision to give a prehospital anaesthetic like:

What are we trying to achieve with this PHEA?
What is the optimum timing?
What is the best location?
Who is the best person to provide it?

At the Great North Air Ambulance Service (GNAAS) before being signed off as acompetent member of our team, we expect our clinicians to have successfully completed this PHEA course and completed a probationary period. This applies for all doctors regardless of previous training and in-hospital practice. Our teams follow a standard operating procedure for the delivery of PHEA and all cases are reviewed through our internal governance panel.

To aid in the decision to perform a PHEA, GNAAS have an approved list of indications for the procedure. They are:

- **Actual or impending airway compromise**- Simple airway manoeuvres should be attempted first before attempting a PHEA. However, in patients who require endotracheal intubation, a drug assisted intubation should be given as soon as appropriate.

- **Respiratory failure**- In trauma or medical patients whose injury or condition is impeding their respiratory function. Attempts should be made to correct the condition prior to the PHEA as certain treatments may improve the patient condition and avoid the need for anaesthesia.

- **Unconsciousness or severely agitated/unmanageable patients**- There are several reasons why a patient may be unconscious or severely agitated. A patient with a traumatic brain injury requires secondary prevention and there is a clear indication for PHEA. However, we should be aware of other reversible causes, such as hypoglycaemia, which must be reversed before a decision to anaesthetise.

- **To facilitate treatment**- Some patients require potentially lifesaving surgical procedures e.g., thoracotomy in a periarrest patient with low output state in trauma.

- **Humanitarian reasons to ease suffering, particularly in multiply injured patients**- Some injuries are so painful or distressing e.g., significant burns. A decision may be made to administer anaesthetic due to the dose of analgesics required or to avoid psychological distress for the patient. This indication requires careful consideration of risk versus benefit.

Contraindications to PHEA are:

- **Inexperienced operator or lack of assistance**- GNAAS mandate that to perform PHEA, there should be at least two people trained and proficient in the procedure.

- **Immediate need for a different intervention/procedure-** For example, decompression of a tension pneumothorax, administration of blood products to name but a few. Attempts to resuscitate the patient before performing PHEA is strongly recommended.

- **Poor access to patient-** This could be a patient who is still trapped in a crashed vehicle or machinery. Ideally, the patient is monitored with good access to the patient.

- **Difficult intubation anticipated-** If this scenario occurs, the operator should have a high threshold for performing the procedure and all attempts should be made to manage the patient without the need for PHEA. If this is not appropriate, the operator should proceed with caution and be prepared to secure the airway by other means.

- **Massive uncompressible haemorrhage-** If the patient has an uncompressible haemorrhage, anaesthetic has multiple adverse effects. Loss of muscle tone splinting the bleed may result in worsened haemorrhage. The induction of anaesthesia will reduce pre-load and remove sympathetic tone with a high risk of inducing cardiac arrest. Wherever possible, this patient should be rapidly transported to an appropriate hospital (preferably one that has surgical facilities) with simple airway manoeuvres in place.

These lists are not exhaustive, and the competent practitioner should always use their discretion and training to decide if a person is appropriate to receive a PHEA. When making this decision, one should always consider the risks and benefits to the patient and themselves.

Risk vs Benefit

RISK	BENEFIT
• Failure to oxygenate	• Securing the airway
• Failed intubation	• Protection from aspiration
• Misplaced tube- oesophageal or endobronchial	• Improved oxygenation
• Hypo/Hyperventilation	• Improved ventilation (EtCO2 control)
• Barotrauma/Pneumothorax	• Hands free management
• Cardiovascular instability due to positive pressure ventilation or drug induced instability	• Ultimate pain control
• Raised Intra-cranial pressure in response to laryngoscopy	• Faster passage through resus/earlier definitive care
• Exacerbation of a c-spine injury	
• Anaphylaxis/bronchospasm	
• Aspiration	
• **DEATH**	

When performing an assessment of the patient to decide whether he/she is suitable for a PHEA, GNAAS advocates a CABCDE approach.

Airway

When assessing a patient's airway, one should use approved assessment techniques. The 'LEMON' mnemonic describes a defensible assessment.

LEMON airway assessment:

Look- externally (obesity, short neck, small mouth, beard, facial trauma, overbite, false teeth)
Evaluate- the 3:3:2 rule (3cm mouth opening, 3cm distance tip of chin to hyoid bone, 2cm between hyoid bone and thyroid notch)
Mallampati score
Obstruction (foreign objects, secretions, neck mass or swellings, stridor)
Neck mobility- degenerative disorders or immobilisation for protection of c-spine

The Mallampati classification is described and used in elective anaesthesia. In many prehospital patients, particularly those who are injured, it will not be possible to assess. Awareness of the classification and its application is encouraged.

The Mallampati Classification- This classification predicts the more oral structures viewed improves the ease of endotracheal intubation and improved view of the vocal chords.

A thorough assessment of the airway should be performed as this may alter the operator's threshold for intubation.

Special consideration should be made for patients with burns or facial trauma. This is because although the patients may have a clear and patent airway on initial inspection, the airway can quickly deteriorate due to the insult. In a burns patient, the burn to the soft tissues of the airway can result in oedema, which has the potential to occlude the airway. Early appropriate intervention is desirable in this patient. Likewise, secretions or blood can cause complications when trying to secure a patient's airway after they have sustained a maxillofacial injury. These patients should only be laid supine when ready to pass the tube. Early intervention and careful planning should dominate when managing this patient group.

Breathing

As part of the ABCDE approach particular attention should be paid to patients displaying signs of respiratory distress or ventilatory failure. Using a 'look, touch, listen' approach will give a clue as to what may be causing the patient's condition. The use of ultrasound is also useful to determine if the patient is suffering damage to underlying structures shown by evidence of fluid (blood/oedema) in the chest or barotrauma such as a pneumothorax.

It is worth bearing in mind that some causes of respiratory distress may be treatable without a PHEA. A simple pneumothorax may require a thoracostomy with a chest drain. However, other signs may make it more obvious that the patient requires a PHEA e.g., a flail segment with respiratory failure, reduced O_2 saturations on high flow oxygen therapy and decreased level of consciousness.

Circulation

The effects PHEA may have on the cardiovascular system (CVS) must be considered.

- Anaesthetic drugs may cause hypotension- opioids are commonly use as part of the anaesthetic regime. A side effect of the opioid drugs is vasodilation and therefore a reduction in blood pressure. The blood pressure should be normalised, appropriately for the patient, using intravenous fluids or blood products.
- Loss of abdominal tamponade may cause CVS collapse- in the shocked patient with intra-abdominal bleeding, the body responds by muscular contraction to 'splint' the abdomen and slow the bleeding. When muscle relaxants are given (e.g., Rocuronium or suxamethonium), they eliminate muscle tone and may release the tamponade.
- Positive pressure ventilation may also cause CVS collapse- positive pressure ventilation causes higher intrathoracic pressures which impedes preload, afterload and ventricular compliance which leads to decreased cardiac output. In a hypovolaemic patient this increases risk of cardiac arrest.

Disability

Accurate assessment of the patients GCS is a must when it comes to treating head injured patients and patients with a reduced level of consciousness. The reason being that once the patient undergoes a general anaesthetic, it cannot be reassessed without waking the patient. It allows receiving staff at the hospital to understand the patient's condition prior to PHEA and may also indicate a possible cause.

The patient's pupils should be monitored whilst in the care of the practitioner. Changes to pupil size and reactivity to light may indicate that the patient is experiencing changes in their physiology e.g., a blown pupil may suggest that the patient has increased intracranial pressure causing herniation of the brain through the foramen magnum.

As always, consider other causes of decreased levels of consciousness before providing a PHEA e.g., alcohol, drug use, hypoglycaemia. This may avoid risk to the patient and embarrassment at a later stage.

Environment
Assess the environment to identify the most appropriate place to perform PHEA. Use all available equipment and personnel to your advantage and use a team approach.

Below is a list of environmental considerations to make before attempting the PHEA.

- Hazards, access and egress- Consider this as early as possible ensuring an egress route. You do not want to anaesthetise a patient only to find you cannot extricate the patient from the environment.
- Mode of transport- transportation modes all have their benefits and limitations. For example- ambulance transfer may be slower over long distances, however they are a more stable platform and can stop if required for patient management. A helicopter is quicker over long distances but less spacious and unable to stop for patient management.
- Weather- Shelter from the wind and rain are likely to improve the patients experience and reduce the discomfort for the clinicians, which will positively impact on the patients care.
- Light conditions- Darkness or bright sunlight can impact on the ability of the operator to visualise the vocal cords. If possible, have a well-lit area with the light source behind you.
- Distance from the nearest hospital/MTC- Being able to perform a PHEA does not mean it is always appropriate. Ask yourself, do I need to anaesthetise this patient here? If the hospital is close at hand, the answer may be ‘no’.
- Human factors- Do I have the correct personnel to carry out this procedure and do they understand their role? If the answer is 'no' to any of these questions you should consider if a PHEA is appropriate.
- Single vs multiple patients. In a multiple casualty incident, it may be necessary to triage patients and consider the most appropriate intervention(s).

It is evident from this chapter that providing a PHEA is not always straight forward. Careful consideration should always be made as to whether the procedure is appropriate to the patient’s condition but also where and when it should be performed.

Have an exit plan!

There is an almost inevitable loss of momentum and energy in a scene after a general anaesthetic is given. The patient stops giving many of the subtle hints of critical illness like raised respiratory rate and the agitation and stress of a partially obtunded patient is taken away. It is your responsibility to continue to drive the scene forward and ensure that you progress a plan for the patient reaching definitive care.

Therefore, plan your exit prior to delivering an anaesthetic. Is the ambulance facing the right way? Is there a way of safely getting out of the house with the now obligatory ventilator and monitoring? Have you considered the most appropriate destination for this patient?

As part of this planning ensure that you have enough consumables to last the journey and then some spare. This includes oxygen but also sedation, paralysis, battery for your monitor and ventilator.

Pre alert the receiving hospital. Remember that it is rare that you can give too much warning and that in many cases in the current environment Emergency Departments are likely to need to create capacity. Even in a major trauma centre it takes time to get blood from the lab, run through a rapid infuser or request the presence of specialist teams like cardiothoracic surgeons.

Ensure the plan is shared and actions to achieve it are clearly articulated with the team.

CHAPTER TWO

THE SIX 'P's OF PHEA

The act of performing a PHEA can be a challenging experience. This can be more challenging due to time pressures, an unstable patient, limited resources, and a difficult environment.

To aid the critical care team, GNAAS advocate the use of the 6 'P's as a mnemonic to help navigate the process.

The following chapter aims to discuss each 'P' and explain what considerations should be made at each stage. The 6 'P's represent:

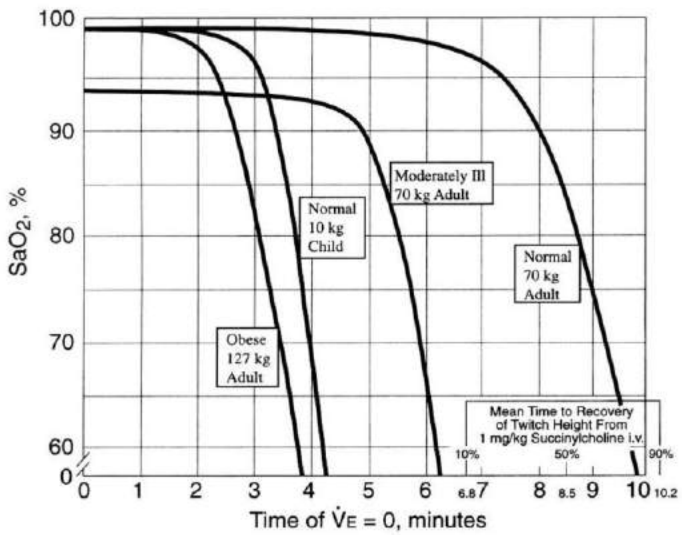
1. **P**reoxygenation
2. **P**reparation
3. **P**remedication
4. **P**aralysis and sedation
5. **P**assage of the tube
6. **P**ost Intubation management

Preoxygenation

The process of the PHEA begins with preoxygenation, which should be commenced at the earliest opportunity. The aim of this step is to replace all air in the patient's lungs with oxygen. This is described a denitrogenation of the lungs. When the patient becomes apnoeic (after induction of anaesthesia), the lungs are a reservoir of oxygen, and this extends the length of time they may remain apnoeic with safe oxygen saturations.

Studies have shown that many factors will influence how rapidly a patient will desaturate once they become apnoeic. The graph below shows the average desaturation times in normality for adults and children, the obese and moderately ill adults. The obese, normal children and moderately ill adults desaturate faster than a normal healthy adult.

TIME TO HEMOGLOBIN DESATURATION WITH INITIAL F_AO_2 = 0.87



Benumof, JL, Dagg, R, Benumof, R. Critical hemoglobin desaturation will occur before return to an unparalyzed state following 1 mg/kg intravenous succinylcholine. Anesthesiology 1997

Patients seen by prehospital critical care teams are at increased risk of rapid desaturation. The clinician should aim to optimise the conditions by effective preoxygenation.

Preoxygenation techniques vary depending on the patient's condition. This may be achieved by delivering oxygen via a Waters circuit or a bag-valve-mask. Stafford et al, 2007, demonstrated that the Waters circuit is the superior method for preoxygenation when compared to the bag-valve-mask, although they discussed the potential benefits of a self-inflating bag. We do not recommend preoxygenation using a well-fitting non-rebreathing oxygen mask. Groombridge et al, 2017, demonstrated that a non-rebreathing oxygen mask was significantly worse for preoxygenation when compared to a bag-valve-mask or ventilator.

Some clinicians advocate for the use of 'apnoeic oxygenation'. This involves maintaining an open airway with the delivery of high flow oxygen via nasal cannula during the apnoeic phase. GNAAS has considered this intervention and do not routinely use.

The guidelines for the management of tracheal intubation in critically ill adults, 2018, advocate for assisted ventilation both at the onset of apnoea before attempting intubation and between attempts. Assisted ventilations are delivered with the intention to extend the time to desaturation. Caution should be exercised as there is a risk of gastric insufflation and therefore an increased risk of aspiration. This risk can be mitigated by good airway management and attention to detail regarding tidal volume.

Preparation

This is a multi-stage process of PHEA which includes:

- Rapid assessment
- Positioning of patient and team
- Preparation of the 'kit dump'
- Protection of the patient including c-spine immobilisation (where appropriate) and cricoid pressure

Rapid assessment

This is performed by the team leader, whilst the assistant is concurrently addressing the next section.

When approaching the scene, the experienced clinician will use all information available to them to assess the patients actual or potential condition. This is a process known as 'reading the wreckage'. By looking at damage to vehicles and surrounding items, one may be able to deduce the severity of the patient's injuries. For example, look at the following pictures. What injuries do you suspect the patient may have? How serious? Consider the forces and speeds involved.

Pic.1 suggests a lower acuity incident as the car has little damage.

Pic. 2 however shows a lot of damage to the rear of the car and intrusion into the rear compartments of the car suggesting a large impact to the rear quarter and potential life-threatening injuries to any rear seat passengers.

Pic. 3 shows bullseye damage to a windscreen, which is suggestive of a patient with a head injury.

It is important to gather demographic information about the patient early. This should include their name, date of birth and address, where possible.

The clinician should consider seeking an AMPLE history:

- Allergies
- Medications
- Past medical history
- Last ate
- Events

The clinician should then go on to perform a primary survey using a **CABCDE approach**.

In the case of trauma, it is advised to strip the patient of all clothes to allow a thorough assessment.

Suitable monitoring devices should be applied at the earliest opportunity with a minimum of 3-lead ECG, NIBP, and SpO2.

C

Catastrophic haemorrhage

This is the first and most vital stage. A rapid visual assessment to determine if the patient is bleeding either internally or externally. In the case of external haemorrhage, devices such as splints, tourniquets and pressure should be applied to stem the bleeding.

A

Airway

Assess the airway for obstructions and suction/clear anything occlusions. The airway should then be assessed using the LEMON assessment tool described in chapter 1. It is also worth verifying that the patient is being pre-oxygenated at this point and assign another person to monitor the airway.

B

Breathing

The persons breathing should be assessed for adequacy, rate, and depth. A tactile examination of the chest should also be carried out. This may find an injury to the chest wall by the presence of signs such as crepitus, flail segments or the presence of surgical emphysema. Other tools can be used such as auscultation, percussion, pulse oximetry or portable ultrasound to identify injuries. REMEMBER to check the patient's posterior chest wall.

C

Circulation

Signs of shock should be identified at this step if not already noted. These include tachycardia, hypotension and signs of pallor and diaphoresis. If the patient has no signs of external haemorrhage, consider other causes of shock or a non-compressible internal bleed. If the latter is suspected, rapid transport to hospital should be considered at the earliest opportunity. Asses the patient's pulses noting any changes in presence, rate, and volume. The team should aim to have all compressible haemorrhage stemmed and at least 2 points of working intra-circulatory access.

D

Disability

This involves assessing the patient's GCS and pupil condition. In the cases where the patient is displaying injuries to their nervous system e.g., an isolated spinal injury, a more in-depth neurological assessment can be performed.

E

Exposure

Check the rest of the patient including abdomen, pelvis, and limbs for injuries. Once identified and managed, the patient should be kept comfortable and warmed, if appropriate.

Patient position and preparation of the 'kit dump'
Performed by the assistant, whilst the team leader is addressing the rapid assessment.

The kit dump is a term used to describe the identification and preparation of a suitable area to prepare all the relevant equipment required to perform a PHEA.

The area identified should be well lit, protected from the elements and, ideally, have the patient raised off the ground with sufficient access to provide treatment to the patient.

The kit dump may not always be next to the patient but in a different, more appropriate, location. The team must consider how difficult it can be to move a paralysed intubated patient. There is significant risk of endotracheal tube displacement and the harm that may result. Patient handling is more challenging in the presence of paralysis. The patient should be extricated and moved to the kit dump so the PHEA can be performed more effectively. It is strongly recommended that the patient is moved to the ground floor, or the ambulance, before delivery of PHEA to minimise the risk of complications.

The patient should be positioned to optimise laryngoscopy and first pass success. This is key to successful intubation and patient safety. Positioning the patient in a ramped, or head elevated, position is advocated. Approximately 25 degrees is recognised to improve both pulmonary compliance and intubating conditions. This can be achieved by positioning the patient on the ambulance trolley and elevating the head of the trolley.

The preparation and layout of the kit dump is at the discretion of the assistant and will differ depending what organisation the team works in.

At GNAAS, we opt to decant all items on to a clean surface e.g., a sheet or clinical waste bag. This allows for ease when checking the items off in the check list stage and standardises our approach to the procedure. As, the team may vary from day-to-day, taking a standardised approach reduces risk of errors occurring. Our operational team now use a purpose-made airway roll, which provides a clear area for preparation of the equipment that is to be used.

Prehospital Emergency Anaesthesia

A Plan Checklist

TO BE USED IN ALL CASES REQUIRING PREHOSPITAL EMERGENCY ANAESTHESIA OTHER THAN THOSE INDICATED FOR B PLAN BELOW

Challenge	Response
Pre-oxygenation	Check
O_2 cylinder >50% & O_2 backup	Check
Bleeding controlled	Check
TXA given	Check
Patient positioning – 360° access, Stretcher	Check
IV/IO x2 connected to fluid and running easily (one if crash)	Check
Suction unit working and positioned	Check
Back up suction available	Check
Patient monitor on and connected	Check
BVM / **Mapleson** available	Check
Ventilator working and set up	Check
Drugs	
Pre-medication?	Yes/No
Fentanyl dose, if required	Check
Induction agent dose	Check
Rocuronium dose	Check
Maintenance drugs and dose	Check
Laryngoscopes: 2 blade sizes working and spare	Check
Bougie ready	Check
ETT size chosen and tested, backup available	Check
10ml syringe	Check
Catheter mount connected to HME filter ready	Check
Tube tape available – consider tie	Check
Capnography	Check
Stethoscope	Check
Airway adjuncts – OPA and 2 NPA available	Check
IGel – size chosen and available	Check
Emergency Surgical Airway kit available	Check
Brief 30 second drills and failed intubation plan	Check
Team positioning and brief (Drugs, MILS, Cricoid)	Check

Once all items have been checked for function, the checklist should be used to ensure all items are there and ready for use.

GNAAS advocate a challenge-response approach to using the checklist i.e., the team leader reads the checklist whilst the assistant acknowledges and identifies the piece of equipment. By using this technique, you avoid missing anything which could complicate the procedure later.

Finally, before passing the tube, the team leader, assistant, and any other personnel involved should have a brief discussion about their plan. Duties should be assigned appropriately – see chapter 4. This ensures a shared mental model and encourages a team approach to ensuring patient safety. Only once everyone involved is happy to proceed, should the induction occur.

Protection

If the patient has sustained a c-spine injury (actual or suspected) and requires a PHEA as part of their management for their injuries, the c-spine should be protected using manual in-line stabilisation (MILS). Cervical collars should be removed and replaced with MILS as this allows for greater control during laryngoscopy.

Cricoid pressure (Selick's manoeuvre) is a technique that was commonly used with the aim of improving the view of the vocal cords whilst reducing risk of aspiration. The manoeuvre involves applying 30 N (3 kg) of pressure to the cricoid cartilage directed posteriorly to occlude the oesophagus. The evidence base for its effectiveness is poor and some practitioners have abandoned its use. It is at the discretion of the operator as to whether it is used. The operator must consider the potential for harm in the presence of cervical spine injury as the pressure is being applied against the spine.

Pre-Medication- (if necessary)

Patients who are agitated or combative may require some medication to facilitate management including pre-oxygenation, positioning and eventual PHEA. The options are discussed in chapter 3, Pharmacology of PHEA.

Paralysis AND Sedation

Paralysis and sedation of the patient are achieved with medications. Details of medications are covered in chapter 3, Pharmacology of PHEA.

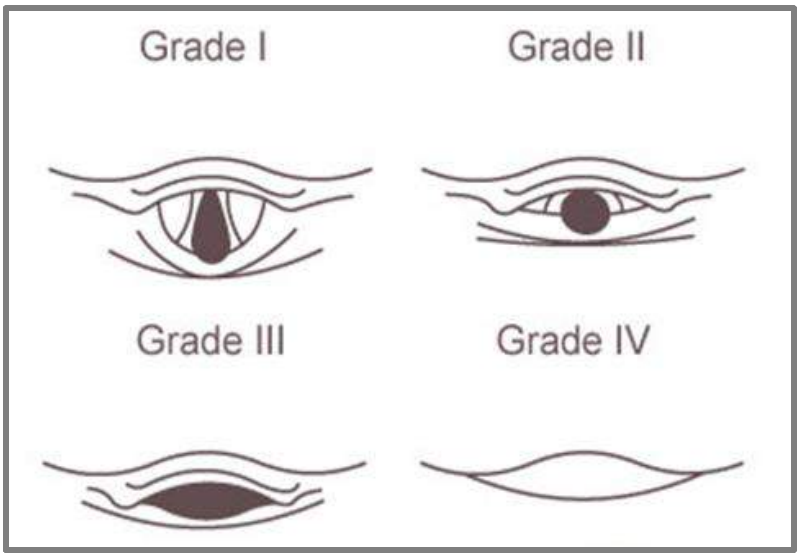
After the drugs have been administered the laryngoscopist should expect to wait for 45 seconds prior to assessing for paralysis. Patients in a low-flow state may have delayed paralysis as circulation and onset of action is slowed. Maintenance of oxygenation is important during this phase, as described earlier in this chapter.

Passage of the tube

GNAAS standard operating procedures advocate for drug assisted intubation. Before an attempt is made to pass the tube, the patient should be adequately sedated and paralysed.

Laryngoscopy should be smooth and not rushed paying particular care not to over-insert the Macintosh blade. Laryngoscopy is a stimulating procedure, which if performed incorrectly can precipitate harmful increases in intracranial pressure.

GNAAS advocates the routine use of a bougie. This maximises the likelihood of first pass success and minimises the risk of oesophageal intubation.



It is best practise for the laryngoscopist to verbalise what they can see during laryngoscopy. This promotes situational awareness and helps the assistant to pre-empt what may be needed to improve visualisation of the vocal cords.

Use of the Cormack and Lehane classification of laryngoscopy views should be routinely used; see left.

To improve first pass success, the team should consider the position of the patient, position of the laryngoscopist and the equipment required for the size of patient. Every effort should be made to optimise all these factors before the first attempt.

To improve intubation success there are several manoeuvres and techniques that can be employed to improve your view of the cords. The following might be considered:

- Repositioning the patient
- Repositioning the laryngoscopist
- Changing the equipment (e.g., blade sizes, tube size or using adjuncts)
- BURP (*see chapter 6*)
- Bimanual laryngoscopy (*see chapter 6*)
- Releasing cricoid
- Changing laryngoscopist

This should not come at the detriment of the patient condition and if a change will take time, consider temporarily ventilating the patient whilst the change is made before a second attempt.

No more than 2 attempts should be made. If the second attempt has been unsuccessful the failed airway plan should be implemented, this is covered in chapter 6.

GNAAS does not currently use video laryngoscopy (VL). Where VL is available, the team should consider and articulate whether and how it will be used during the preparation phase.

<u>Post intubation management</u>

After the tube has been successfully seated in the trachea, post intubation checks should be carried out.

1. Inflate the cuff to the recommended air pressure and check for air leaks.
2. Confirm placement of the tube by checking for:
    i. Fogging of the tube
    ii. Chest movement
    iii. Auscultation of the chest for breath sounds
    iv. Confirm the presence of a waveform on the capnograph.
3. Release cricoid pressure (if applied)
4. Secure the tube
5. Reassess the patient condition and vital signs
6. Give on-going sedation, see chapter 3.
7. Prepare to move the patient to hospital

This is covered in more detail in chapter 5.

CHAPTER THREE

PHARMACOLOGY OF PREHOSPITAL ANAESTHESIA

In hospital anaesthesia there are a range of pharmacological agents in use for premedication, induction, paralysis, maintenance and to counter the adverse effects of those drugs. Each anaesthetist will select the combination of agents that they believe will provide their patient the best anaesthetic for their individual circumstances. Much of this practise is pre-planned, rehearsed and learned. The environment and staff team are managed to provide consistency and familiarity, which reduces the potential for heuristic errors.

In prehospital practise we aim to standardise our procedures so far as is possible to reduce risk for our patients. We work in challenging environments and our patients have a multitude of injury patterns or critical illness with potential for diagnostic uncertainty; these factors increase the risk of error by introducing heuristic challenges. The consistency provided by a standard pharmacological recipe for prehospital emergency anaesthesia allows clinicians to build experience of the expected effects and become familiar with the modifications that may be required.

This chapter provides an explanation of the current standard operating procedure used by prehospital teams working for the Great North Air Ambulance Service. The approach that is described has been modified over the last decade of practise by our clinicians based on review of the effects that have been observed. We continue to evolve our practise in accordance with evidence and audit. There are different pharmacological agents in use across prehospital emergency medicine services in the UK and across the world. Our approach is one safe way; It is not the only safe way.

We will consider the aims of anaesthesia and sedation before we look at each stage of PHEA and consider the drugs that are used or omitted. The applied pharmacology of each agent will be described. This manual is not intended to provide the reader with an in-depth knowledge of pharmacology, that can be achieved from the pharmacology literature.

We will now consider the various pharmacological stages of PHEA and the medications that are used by GNAAS.

Pre-medication
Laryngoscopy is a stimulating procedure and may induce a sympathetic response. The sympathetic surge increases blood pressure and may cause a harmful increase of intracranial pressure. To dampen that response, we selectively administer fentanyl.

Fentanyl is a synthetic opioid, which is a clear colourless solution. Neat the concentration is 50 micrograms per millilitre. We stock 2 ml (100 mcg) ampoules.

Fentanyl is administered at 1 mcg/kg, when it is appropriate. We elect not to use fentanyl if the patient is haemodynamically unstable or if the patient has known anaphylaxis to fentanyl. We recognise that fentanyl causes post-induction hypotension in haemodynamically unstable patients; this hypotension is known to be harmful to those with traumatic brain injury and is likely to be harmful to any multiply injured or critically unwell patient.

In some patients a higher dose of fentanyl may be required. Examples of such patients include those with sub-arachnoid haemorrhage, isolated traumatic brain injury or burns.

It is administered neat via either intravenous or intraosseous route. It can be diluted for administration if small volumes are required. When being administered in the context of isolated traumatic brain injury, the administration should be early to allow onset prior to laryngoscopy and reduce the spike in intracranial pressure by blunting sympathetic surge. Onset of action is within 5 minutes.

Side effects of fentanyl include respiratory depression, nausea, vomiting and hypotension.

We do not routinely consider any other premedication. In the context of an agitated patient, it may be necessary to administer medications for procedural sedation to facilitate the delivery of prehospital emergency anaesthesia. Options include:

Midazolam
0.02 mg/kg (1 - 2 mg in adults)

Ketamine
0.25 - 0.5 mg/kg (10 – 50 mg in adults)

Induction
We use **ketamine** as our sole induction agent to maintain consistency. Ketamine is an NDMA receptor antagonist that provides a dose-dependent dissociative state, which at an appropriate dose result in anaesthesia. It may be used for analgesia in severe pain, to provide procedural sedation or as a rescue therapy in life-threatening asthma. It is contraindicated in patients with known anaphylaxis to ketamine.

Ketamine has sympathomimetic effects including tachycardia, hypertension and bronchodilatation. Sub-anaesthetic doses cause significant dysphoria which can include unpleasant hallucinations. A rare side effect is laryngospasm.

Ketamine is a clear and colourless solution, which is available in three concentrations: 10 mg/ml, 50 mg/ml and 100 mg/ml. We carry 50 mg/ml because it provides an opportunity to administer intramuscular or intranasal doses when used neat and intravenous doses after standard dilution.

In preparation for PHEA, we dilute 4 ml of 50 mg/ml ketamine with 16 ml of Water for injection to produce 20 ml of 10 mg/ml solution. This is our standard operating procedure and is the only dilution that is acceptable in our practice.

The dose differs depending on route and indication:

- Induction of anaesthesia: 1 mg/kg (*sometimes 2 mg/kg may be required*) via IV/IO
- Severe pain: 0.25 mg/kg via IV/IO
- Procedural sedation: 0.5 mg/kg via IV/IO, 2 mg/kg via intranasal, or 4 mg/kg via IM
- Life threatening asthma: 0.5 mg/kg via IV/IO

Care should be taken with patients who are frail and/or compromised. Divided doses should be given and repeated, if required.

Propofol is an anaesthetic agent that is used by some services for induction and/or maintenance of anaesthesia. GNAAS does not use propofol.

Muscle relaxant
For consistency, we use only **rocuronium** for neuromuscular blockade and paralysis. It is a competitive antagonist at the neuromuscular acetylcholine receptor and has a rapid onset. It may cause pain on injection and can cause anaphylaxis.

It is contraindicated for patients with known anaphylaxis. Caution should be used if the patient is known to have hypersensitivity to other neuromuscular blocking agents due to reports of cross-reactivity.

Rocuronium is a clear and colourless solution. We stock 5 ml vials of 10 mg/ml (50 mg). Our stock is stored in the refrigerator. We carry it for up to two months out of the refrigerator, after which any unused vials are disposed of. *Manufacturer's guidance is that it may be stored outside the refrigerator at a temperature up to 30°C for a maximum 12 weeks, after which it should be discarded and that it should not be placed back into the refrigerator, once it has been stored outside.*

We administer rocuronium neat at an initial dose of 1.2 mg/kg as a bolus via intravenous or intraosseous route. If a repeat dose is required to maintain paralysis, this is 0.5 mg/kg.

Intubating conditions are achieved in most patients 45 to 60 seconds after administration of rocuronium at this dose.[1.] The clinical duration of action approaches 1 hour with this dose of rocuronium.[1]

Maintenance of anaesthesia
The standard approach to maintenance of anaesthesia for most patients is a combination of morphine and midazolam (M&M). The specifics for each drug will be covered below. For the purposes of maintenance of anaesthesia, the GNAAS approach is to draw up both drugs into a single syringe. This is achieved by drawing 1 ml of Morphine 10 mg/ml and 2 ml of Midazolam 5 mg/ml into a 10 ml syringe and dilute with 7 ml of Water for injection. The solution provides 1 mg of each drug in each millilitre. This is administered in aliquots of 1 to 3 ml depending on patient physiology.

Morphine is an opiate with analgesic, anxiolytic and mild sedative effects. At higher doses it has cardiorespiratory side effects. It commonly causes nausea, vomiting, itching and dizziness. Cutaneous reactions are reasonably common and generally self-limiting. Morphine is contraindicated in those with known anaphylaxis to the drug.

It is supplied as a clear and colourless solution in ampoules containing 10 mg/ml. It is diluted to a concentration of 1 mg/ml prior to administration.

Midazolam is a benzodiazepine, which causes sedation, anxiolysis, amnesia and has anticonvulsant properties. It has cardiorespiratory depressant effects that may lead to hypotension and a reduced respiratory drive or apnoea. It is contraindicated in known anaphylaxis to midazolam.
It is a clear and colourless solution. We stock ampoules containing 10 mg in 2 ml. It may be administered via intravenous, intraosseous, intranasal, buccal or intramuscular routes in the emergency setting.

Midazolam may be used as an induction agent. This is not incorporated within the GNAAS SOP; however it may be appropriate for some patients.

For sedation following PHEA, the dose is titrated to effect and requires the clinician to consider the patients physiology. The usual dose range is 0.01 to 0.05 mg/kg at 10-minute intervals. Midazolam may be used as a sole agent for sedation at the same dose range. If it is being used to prevent or treat the unpleasant dysphoric effects of ketamine the dose is 0.02 mg/kg, repeated as required.

In the anaesthetised patient it is important to be aware of the risk of hypotension with morphine and midazolam, particularly in haemodynamically unstable patients.

Cardiovascular support
Delivering anaesthetic drugs to critically ill and/or injured patients may result in worsening of cardiovascular physiology. Wherever possible, we avoid this by making a detailed assessment of our patient, preparing, and optimising them prior to PHEA and anticipating the potential effects of our interventions. We will seek to identify and treat injuries to stop or reduce bleeding, we may provide resuscitation with intravenous fluids or blood prior to induction, and we may reduce the dose of anaesthetic drugs to avoid adverse post-induction effects. Despite all this we may need to administer drugs to support the cardiovascular system and counter the negative effects of the anaesthetic. GNAAS use adrenaline or ephedrine for this purpose.

Adrenaline is a hormone with sympathomimetic properties. It causes inotropy and chronotropy, increasing the strength of cardiac contractility and the heart rate. It is a bronchodilator. It can cause dysrhythmias. It vasoconstricts, which at high doses can cause myocardial and cerebral ischaemia.

GNAAS carry both 1:1,000 and 1:10,000 preparations.

For low cardiac output states, in adults we would administer 50 micrograms intravenously (0.5 ml of 1:10,000), repeated as required.

It may be given intramuscularly or intravenously. Those who are not experienced in the administration of intravenous vasopressors should not give intravenous adrenaline. The intramuscular route is safer for patients as absorption into the circulation is slower and the risk of serious side effects is reduced. There are no contraindications in life-threatening situations.

Ephedrine is a short-acting sympathomimetic amine. It has both alpha- and beta-adrenergic effects that cause a temporary increase in heart rate, stroke volume and blood pressure.

Pre-filled syringes containing 30 mg of ephedrine hydrochloride in 10 ml (3 mg/ml) are carried by GNAAS. Ephedrine can be administered via IV or IO route. The dose is 3 to 9 mg in adults (1 to 3 ml), adjusted and repeated according to response.
There are no specific contraindications, but it should not be used in isolation where hypovolaemia is contributing to hypotension.

Summary
In summary, for induction of anaesthesia, GNAAS use a **(1) : 1 : 1** recipe.

That is:

- (1 mcg/kg of fentanyl) *Bracketed as it is omitted in unstable or frail patients.*
- 1 mg/kg of ketamine for induction
- 1.2 mg/kg of rocuronium for paralysis

Practitioners of PHEA must be aware that patients in a low-flow state may have delayed onset of action for medications that are administered. This should be considered during all phases of PHEA as the expected action is likely to be delayed and this may impact decision making.

This is a helpful way to recall the doses required and we would encourage you to be familiar with this approach as it will assist you with the practical elements of the course.

References
1 https://www.medicines.org.uk/emc/product/553/smpc#PHARMACODYNAMIC_PROPS (accessed 07/11/2020)
Drug SOP – Fentanyl / Ketamine / Rocuronium / Adrenaline / Ephedrine

CHAPTER FOUR

ROLE ALLOCATION AND KIT DUMP

Although we cannot control all aspects of the environment, we must have standard approaches that allow the prehospital team to offload some of the cognitive stresses. A well-rehearsed approach to the position of the patient in relation to the equipment, how the equipment is laid out (the kit dump) and the team roles that may be required will allow team members to have enough bandwidth to cope with the other challenges they may face.

This chapter will provide an explanation of what roles may be required and what equipment is required when delivering PHEA. It will cover some theory about the position of the patient in relation to the environment, the team and the kit dump. It will provide some options to consider when the laryngoscopist is positioning themselves relative to the patient.

Team roles
The team required to deliver PHEA will be determined by the specific circumstances and requirements of the patient. The absolute minimum requirement is that there is a clinician who is trained to deliver the anaesthetic and a trained assistant working within a system providing clinical governance for PHEA. The specific requirements will be determined by the governance system within which the anaesthetic is being delivered.

There are several specific roles that may need to be performed. Depending upon the patient's presentation and physiology, crew skill mix, number of personnel available and environmental factors more than one of the roles may be performed by one person or each role may be performed by an individual.

Team leader: It is well recognised that heuristics play a part in error, particularly when we are in challenging situations dealing with complex patients. Maintaining team situational awareness is vital to avoiding error. During critical procedures, such as the delivery of PHEA, the Team Leader role must not be downplayed. A hands-off Team Leader is likely to benefit the team as they are less likely to become task focused and are well placed to check and maintain team situational awareness.

Laryngoscopist: This technical role requires a team member who is trained in advanced airway management. They need to be familiar with endotracheal intubation, optimising their first attempt, implementing the failed intubation plan and, if required, the surgical airway. This team member should not normally fulfil any other tasks during the PHEA. Their primary focus must be to appropriately manage the airway throughout the PHEA and post-intubation procedures.

In the event of encountering a difficult airway, it is essential to have pre-briefed what the failed intubation plan will be, and this should include whether any other team member will change into the laryngoscopist role.

Assistant: This is a key role for the delivery of a safe PHEA. The assistant must be trained in the delivery of PHEA and will often be as skilled as the laryngoscopist. They must understand the equipment used during the PHEA, the steps involved in PHEA and the failed intubation plan. They must be able to challenge the laryngoscopist and ensure that they follow the plan.

Drugs administrator: The drugs administrator needs to be familiar with the drugs being used during the PHEA and understand the dose to be administered. This will normally be a member of the critical care team. There are likely to be serious consequences for the patient if an incorrect drug is administered.

Manual in-line stabilisation (MILS): Trauma patients with suspected cervical spine injury must have their neck stabilised. This should be maintained throughout their treatment until an injury is formally excluded. Intubation is a procedure that risks the movement of the cervical spine and, therefore, an appropriately trained team member should be briefed to maintain MILS. They will need to be guided to ensure that they do not impede the safe delivery of PHEA but provide effective MILS.

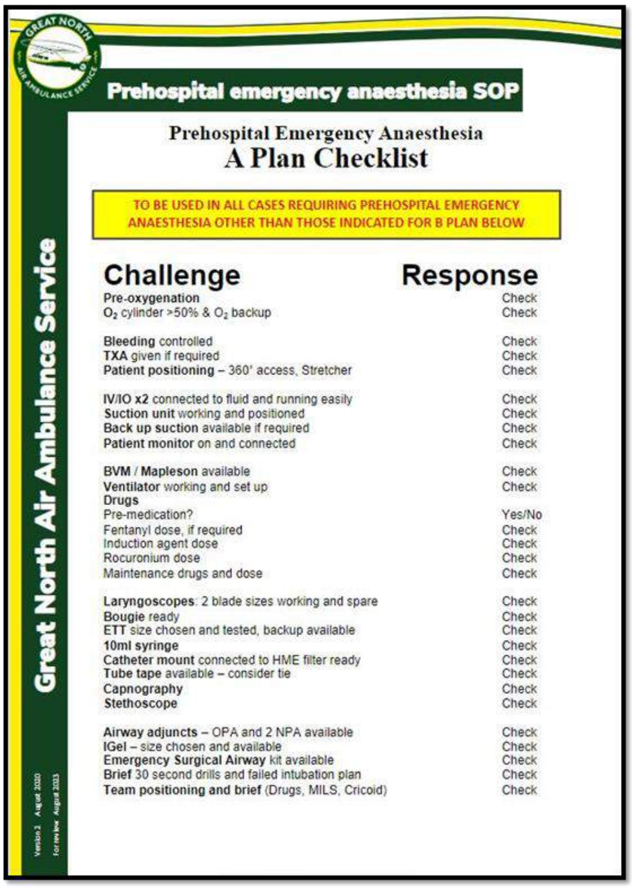
Cricoid pressure: Where it is considered appropriate to apply cricoid pressure, the team member allocated to this role needs to understand the anatomy of the cricoid and how to correctly apply cricoid pressure. It is very useful if they are also familiar with the BURP procedure and bimanual laryngoscopy.

Cricoid pressure is not always implemented. The evidence of benefit is not overwhelming and there is evidence to suggest that it may be harmful.[1, 2] A pragmatic approach should be taken.

[1] https://doi.org/10.1016/j.hrtlng.2019.10.001

[2] https://academic.oup.com/bja/article/113/2/211/264336

Equipment



Great North Air Ambulance Service

Prehospital emergency anaesthesia SOP

Prehospital Emergency Anaesthesia

A Plan Checklist

TO BE USED IN ALL CASES REQUIRING PREHOSPITAL EMERGENCY ANAESTHESIA OTHER THAN THOSE INDICATED FOR B PLAN BELOW

Challenge	Response
Pre-oxygenation	Check
O_2 cylinder >50% & O_2 backup	Check
Bleeding controlled	Check
TXA given if required	Check
Patient positioning – 360° access, Stretcher	Check
IV/IO x2 connected to fluid and running easily	Check
Suction unit working and positioned	Check
Back up suction available if required	Check
Patient monitor on and connected	Check
BVM / Mapleson available	Check
Ventilator working and set up	Check
Drugs	
Pre-medication?	Yes/No
Fentanyl dose, if required	Check
Induction agent dose	Check
Rocuronium dose	Check
Maintenance drugs and dose	Check
Laryngoscopes: 2 blade sizes working and spare	Check
Bougie ready	Check
ETT size chosen and tested, backup available	Check
10ml syringe	Check
Catheter mount connected to HME filter ready	Check
Tube tape available – consider tie	Check
Capnography	Check
Stethoscope	Check
Airway adjuncts – OPA and 2 NPA available	Check
IGel – size chosen and available	Check
Emergency Surgical Airway kit available	Check
Brief 30 second drills and failed intubation plan	Check
Team positioning and brief (Drugs, MILS, Cricoid)	Check

Version 2 August 2020

For review August 2023

This is an image of our checklist, which includes a list of the equipment required to safely conduct PHEA.

Patient monitoring requirements are the same as for in-hospital anaesthesia. Specifically, the critical care team must be monitoring oxygen saturations, capnography, heart rate, blood pressure and electrocardiograph. These requirements are defined in the Association of Anaesthetists, Safer Prehospital Anaesthesia guideline (March 2017).

The Association of Anaesthetists guideline provides direction regarding the equipment that should be used for prehospital anaesthesia. The rationale for the equipment being available will be described.

Sufficient oxygen must be available to deliver preoxygenation and to ventilate the patient throughout the duration of the prehospital phase and transport. It is essential to take account of the ventilator equipment in use, it's driving gas requirement and the ability to maintain patient safety in the event of delays or change in condition. The minimum for transfer is calculated using the formula:

$$2 \text{ x transport time in minutes x } [(MV \text{ x } FiO_2) + \text{ventilator driving gas}]$$

Intubation equipment must include a bougie and spare laryngoscope. We encourage the use of the bougie as a routine when intubating to ensure familiarity with its use and to improve first pass success. Equipment failure may have a catastrophic impact during anaesthesia; It is for that reason that we mandate spare items of critical equipment are prepared, checked, and available.

Suction must be functioning and immediately available during laryngoscopy to allow the management of a soiled airway.

Airway adjuncts and IGel are prepared within the kit dump for airway management in the event of a failed intubation. The failed intubation algorithm escalates through a short series of steps, which may result in a need to perform a surgical airway. Preparing the equipment as part of the kit dump will reduce delay.

Ventilation equipment should include a properly serviced mechanical ventilator. The critical care team must be trained in its use. Rescue equipment must be available and include a self-inflating bag-mask with a reservoir. We carry Mapleson circuits (C for adults and F for children), which allow the critical care team to deliver positive end expiratory pressure (PEEP) during hand ventilation, however they require high-flow oxygen for use. A self-inflating bag can, in extremis, be used without oxygen.

Access to the patient
Controlling or selecting the appropriate environment is important for patient safety. Delivering a prehospital anaesthetic in an inaccessible location is unlikely to benefit the patient and may result in harm. There must be sufficient space around the patient for various team members to fulfil their role(s) and enable the critical care team to access the patient to provide interventions in preparation for, or after, the anaesthetic.

Figure 4.1 shows our preferred team positions and equipment location around the patient. The assistant should be to the right of the laryngoscopist, to enable them to pass equipment into the laryngoscopist's right hand. Where possible, the team member who is providing MILS should be on the left of the patient to allow the assistant visibility of and unobstructed access to the patient.

Figure 4.1

There will be circumstances in which achieving 360-access is difficult. The critical care team should consider options available to them. These may include moving the patient to a nearby place that is sufficiently spacious or moving obstacles in the environment around the patient to make sufficient space. If the risk to the patient of moving them or delaying treatment whilst making space is greater than the risk of limited access, then it will be necessary to take a pragmatic approach.

Intubating positions

The goal for the laryngoscopist is to achieve the best position for them to view the glottis. This can be achieved from a few positions. If the patient can be moved onto an ambulance trolley, as shown in figure 4.2, this is ideal for the laryngoscopist.

Consideration should be given to weather conditions. Bright sunlight will impact on the laryngoscopist's ability to view the glottis if they are facing towards it. Bystanders can be asked to shield the patient and laryngoscopist using blankets or similar.

Figure 4.2

If the patient is on the floor and it is not possible to move them onto an ambulance trolley, there are a few positions that the laryngoscopist may adopt. The selected position will depend on laryngoscopist preference and environmental factors. It may be more comfortable and/or stable in one or other position.

Figure 4.3

Lying requires sufficient space for the laryngoscopist to achieve a prone position at the head-end of the patient.

Figures 4.3, 4.4 and 4.5 show different options.

Figure 4.4

Figure 4.5

CHAPTER FIVE

POST INTUBATION MANAGEMENT

Intubating the trachea is the beginning of critical care and only the first part of prehospital emergency anaesthesia. It is often the aspect most focused upon in courses, the literature and people's mindset however exemplary ongoing management is crucial. It is important that you as a practitioner develop a proactive system for the ongoing management of the intubated and ventilated patient.

In this chapter we will discuss the immediate post intubation management followed by the post intubation resuscitation and treatment. We will also consider the importance of driving the scene forward.

Immediate Post intubation management

Immediately post intubation perform a brief ABCDE assessment. This is not a repeat of your primary survey so much as an assessment to confirm if your intervention has altered the signs or physiology in a positive or negative fashion. You should confirm your priorities for the next 5 to 10 minutes.

Check the ET tube remains in the trachea, at the correct length, and appropriately secured. It is mandatory that this is done via waveform capnography. Diligence should be paid to the possibility of displacement of the endotracheal tube, this is often noticed by falling and then absent end tidal carbon dioxide and lack of chest wall movement.

The length of the tube at the teeth should be checked and adjusted for the patient. The appropriate length will vary depending upon the patient; however, 22 to 24 cm is an acceptable starting point in an average adult. Bear in mind that endobronchial intubation can occur as low as 19 cm in some short adults. The correct length for children will be documented in your services guidelines or APLS.

Confirm the presence of bilateral chest wall movement. If chest wall movement is significantly unilateral, consider the presence of either endobronchial intubation or tension pneumothorax.

Check a full set of observations, particularly oxygen saturation and blood pressure.

Begin your plan for ongoing sedation and exit, which was discussed in chapter 1.

Post Intubation Resuscitation and Treatment

Prehospital emergency anaesthesia is often used as a gateway to facilitate other emergency interventions which were not possible prior to the anaesthetic. These should be implemented in a planned fashion rapidly after the anaesthetic is safely delivered.

If thoracostomies are expected to be required, a brief reassessment to confirm the necessity may be valid. However, positive pressure ventilation can be expected to complicate a significant but non-tension pneumothorax rapidly into a tension pneumothorax. This should ideally be treated before it causes significant physiological abnormality. Significant hypotension or tracheal deviation are late signs, and our goal should be to avoid these.

Treatment of a significant pneumothorax in a ventilated patient is by an open thoracostomy. A formal chest drain takes too long, and needle decompression is generally inadequate except as a temporising measure if the skills to provide a thoracostomy are unavailable. It is reasonable to perform a unilateral thoracostomy and reassess.

Splintage of limbs and the pelvis should in most circumstances be performed prior to delivering an anaesthetic. However, in some cases of severe agitation this may not be possible and in these circumstances, they should be delegated to competent staff to perform as soon as possible after the anaesthetic.

Plan for and expect occult haemorrhage to become apparent or be exacerbated by the loss of sympathetic tone and increased intrathoracic pressure related to general anaesthesia. Fluid resuscitation should be initiated or continued, if indicated.

Breathing and Ventilation Strategies

Ventilation strategies will vary depending upon the patient, pathology, system, and practitioner. There are some guiding principles that are important, which will be discussed.

Ventilation should be transferred to a mechanical ventilator wherever possible. Mechanical ventilators deliver a far more reliable rate, volume and allow for easier adjustment of FiO_2 and PEEP. The mode of ventilation will vary depending upon your ventilator and service however it is reasonable to aim for lung protective ventilation in the first instance for all patients. This means aiming for 6 - 8 ml/kg, so around 400-500ml in an average adult. This volume is chosen as there are studies suggesting it does less damage to the lung than higher volumes. Higher volumes can be chosen, if necessary, but they are rarely needed in the context of prehospital care. One should generally avoid peak pressures above 30 cmH_2O to prevent barotrauma to the lungs.

One of the key benefits of a prehospital emergency anaesthetic is the control of arterial carbon dioxide in the patient with a brain injury. This is measured using end tidal carbon dioxide to which it relatively closely approximates. Carbon dioxide clearance by ventilation is a function of minute ventilation, which is calculated by multiplying the tidal volume by respiratory rate. **You should aim for an end tidal carbon dioxide measurement of 4 to 4.5 kPa.**

Allowing for a relatively fixed tidal volume, the easiest way to control the arterial carbon dioxide pressure is to alter the rate. When ventilating patients in a lung protective strategy with lower tidal volumes than was previously taught (6 to 8ml/kg as above) it is common to need higher rates. It would be acceptable to start between 14-16 and in some cases, you will need to go up 20-26 breaths/min.

Throughout ventilation attempts should be made to measure oxygen saturation, accepting that this can often be difficult in the shocked patient. With few exceptions saturations should be maintained between 94% and 98%. This is best managed by titrating the inspired oxygen.

PEEP can be difficult to balance in the prehospital setting. It is the constant pressure applied to the lungs throughout ventilation, and therefore measured as a pressure applied even when expiration is occurring. The pressure curves of a patient with and without PEEP are described below.

PEEP prevents collapse of the alveoli within the lung and can alter lung compliance making the patient easier to ventilate even though the starting pressure is higher. Its use in prehospital care is to improve oxygenation. The primary disadvantage is that the increased intrathoracic pressure can have a negative effect on the circulation of patients who are intravascularly depleted. There are some advocates for no PEEP in the care of patients with an injured brain however we advocate for a low PEEP strategy in this case. **A good starting point would be a PEEP of 5 cmH2O.** This can be increased in a patient with primary lung pathology whom you are struggling to achieve adequate oxygenation. It can be decreased in a patient with shock and untreatable hypotension.

Ventilation in Special Circumstances

Some patients require more complex management approaches, two of which we will discuss here.

For patients with significant isolated chest injuries or illness, the balance of risk shifts towards oxygenation and lung protection and away from management of CO2. In these patients an increase in PEEP to 10 (rarely 15) and smaller tidal volumes more frequently may allow for adequate oxygenation whilst not delivering damaging pressures to the lungs.

Patients with asthma and COPD are generally very difficult to ventilate. Care should be given to avoiding intubation except when absolutely necessary. Due to significant bronchospasm passive expiration takes significantly longer than normal. If full expiration is not allowed prior to the ventilator delivering the next breath then air can become 'trapped', building up and causing combined obstructive shock and failure to ventilate. Aim for a low respiratory rate, long expiratory time and expect the CO2 to climb. Even with high pressures low volumes will occur but this is acceptable as long as you are oxygenating.

Circulation Management

Two IV cannula is ideal but balance the benefits of a spare line versus further time trying to gain access, especially for short transfer times. Ensure the blood pressure is set to cycle every 3-5 mins and that you have a 3 lead ECG attached.

As mentioned above, ensure that you have managed both internal and external haemorrhage as best you can to minimise ongoing blood loss. Correct significant haemorrhage ideally with blood products.

The exact blood pressure to aim for depends on the balance of pathologies in play. For a true isolated brain injury, the **mean** arterial pressure should be targeted around 90 mmHg. For patients with non-compressible haemorrhage there is evidence of benefit in maintaining a relatively short period of hypotension with a **systolic** around 80 mmHg although this is compared to volume replacement with crystalloid not blood. The balance of these two imperatives in the multi-injured patient is difficult.

However, you should plan for hypotension and establish a patient specific strategy for managing this based on your local protocols. This may include IV fluids, bloods products or vasopressor use, all of which have their place.

Sedation and Disability Management

Adequate sedation is essential for humanitarian reasons, prevention of secondary brain injury and to allow continued effective ventilation.

Whilst ketamine, as an induction agent, will have a continued effect for around 10-15 minutes many sedative agents take a while to reach significant tissue concentrations, so you should plan for this early. There are several regimes available including boluses of opiates/benzodiazepines, further ketamine, propofol or various mixes of the above. The aim is to ensure adequate sedation balances against the vasodilatory effect of the drugs you have chosen. All sedation agents, including ketamine, have a variable influence on blood pressure meaning that patients may respond differently; do not be fooled into thinking ketamine is entirely cardiovascularly stable.

Ongoing paralysis is important for two reasons: 1) It prevents coughing (and therefore raises in ICP). 2) It allows for improved synchrony with the ventilator especially with relatively simple transport ventilators. Rocuronium has a variable offset time especially in the large doses used for PHEA and after divided doses. It is reasonable to plan for an additional 0.5mg/kg around 40 mins after induction, further doses should be based on clinical response.

Pupils should be assessed before, after and throughout anaesthesia.

Care should be given to the management of ICP in those whom a closed brain injury is suspected. This includes:

- Maintain ETCO2 4-4.5 kPa. This influences vasoconstriction/dilatation to balance brain oxygenation against the pressure effects from blood volume.
- Sats 94-98%. Hyperoxia and hypoxia are bad for the injured brain.
- MAP of around 80-90 mmHg *although note the comments above about increased bleeding in the multiply injured patient*
- Deep Sedation. The goal here is to decrease cerebral oxygen demand by sedation. This is balanced with the blood pressure lowering effects of most sedation agents and you may need to plan to counteract this with vasoconstricting agents.
- BM should be measured and corrected if low. We do not advocate correcting high blood sugars with insulin in the prehospital phase.
- Positioned with 30 degrees head up, where possible, to facilitate venous drainage from the head.

- Encourage smooth and sensible driving. Slow, planned, and controlled movement will minimise changes in intracranial pressure, which are caused by rapid acceleration and deceleration forces.

If the patient shows signs of significantly raised ICP (abnormal pupillary response, BP/HR abnormalities) despite the above management then additional consideration should be given to lowering ICP:

- Hypertonic saline is the treatment of choice, mannitol is also available.
- If hypertonic saline is unsuccessful a brief period of hyperventilation (aiming for a ETCO2 of 3.0-3.5 kPa) can be considered. This lowers ICP but possibly at the expense of cerebral perfusion.

Exposure

Temperature management is crucial in any anaesthetised patient let alone one in the outside who is critically unwell. Patients who are anaesthetised and paralysed lose the ability to shiver or alter their behaviour to prevent heat loss.

Hypothermia negatively affects prognosis in most conditions that critical care services attend. The possible exception would be for neuroprotection following VF arrest but the evidence for this is fading. Crucially for us hypothermia in haemorrhagic shock is adverse and once it has begun is extremely difficult to reverse in the context of a patient needing prehospital, ED and then possibly operative management. To prevent this all patients who have received a general anaesthetic should be warmed using a warm ambulance, blankets and active warming using heated blankets of some sort.

Ensure that your IV access (IO, CVC, peripheral cannula) remain patent and easily accessible for the position your patient will be in for transport. If necessary, place additional IV access and secure it well but don't extend your time on scene with protracted attempts to secure backup access.

Exit plan

If you haven't already, you should be moving to hospital by enacting your exit plan.

CHAPTER SIX

FAILED INTUBATION

Planning and preparation prior to prehospital emergency anaesthesia will increase the chance of a successful endotracheal intubation and can be divide into three main components: Personnel, Position and Equipment. Optimisation of intubating conditions will be considered here before a discussion of the algorithm for management of failed intubation.

Personnel

Whilst the GNAAS critical care team generally consists of a doctor and paramedic, there will be varying skills and expertise within the team. For example, an anaesthetist will be a relative expert in the skill of intubation. In the case of a predicted difficult intubation the most experienced laryngoscopist should make the first attempt to intubate, therefore maximising the chance of first pass success.

A plan to change laryngoscopist, in the case of failed intubation, should also be considered prior to PHEA.

Position

Positioning should be considered and optimised prior to PHEA. Both the laryngoscopist and the patient should be positioned to provide a comfortable and clear view of the glottis. The chosen positions will be influenced by the patient's pathology, the scene, environment, and available resources.

The actual position is not in itself important if it is the one that suits the laryngoscopist and maximises their chance of success.

Poor patient positioning is perhaps the most likely cause of failed intubation and so it is essential to optimise this prior to PHEA. Ideally the patient should be raised up on a trolley, so the head is at the laryngoscopist's eye level. The '*sniffing the morning air*' position is most often described as the ideal position and is achieved by flexing the neck and extending the head.

The '*sniffing the morning air*' position involves flexion of the lower cervical spine and extension at the atlantooccipital joint, so risks further damage in the case of cervical spine injury. In these patients, manual in-line stabilisation (MILS) is performed to reduce head and neck movement at laryngoscopy.

Techniques to improve view at laryngoscopy

External laryngeal manipulation can improve the view at laryngoscopy, the most common described technique is the application of Backwards Upwards Rightwards Pressure (BURP) on the cricoid cartilage; this pushes the cricoid posteriorly and laterally away from the tongue therefore improving view. When performing this technique in the patient with potential c-spine injury posterior movement of the c-spine can be avoided by placing a second hand at the back of the neck to counter cricoid pressure.

Bimanual laryngoscopy is a term that describes the laryngoscopist using their right hand to manipulate the cricoid cartilage to improve their view. An assistant should first take hold of the cricoid cartilage with their thumb and first finger. The laryngoscopist should grip the assistant's hand and manipulate it whilst visualising the glottis. When an improved view is achieved, the laryngoscopist should tell the assistant to maintain their position. When they are confident that the assistant is ready and understands the instruction, the laryngoscopist should release their grip freeing their right hand to proceed with intubation.

Equipment
Pre-oxygenation, ideally with continuous positive airway pressure via a Mapleson C circuit, will maximise the apnoeic time prior to desaturation and allow more time to manage the unanticipated difficult airway.

The most appropriate size of both the laryngoscope and endotracheal tube should be considered prior to PHEA, and alternative sizes should be immediately available.

Suction must be prepared and immediately available to enable the clearing of a soiled airway. A back up suction should be available in case of failure of the first unit.

Indirect laryngoscopy with a video laryngoscope may allow easier visualisation and intubation of the larynx in patients who cannot be ideally positioned. However, this may be a slower technique than direct laryngoscopy and can be limited when there are large amounts of blood, secretions, or vomit in the airway. GNAAS does not currently utilise video laryngoscopy.

A bougie is used routinely and may compensate for the acute angle at which the larynx is viewed in the patient who is not ideally positioned, such as the patient with suspected c-spine injury and MILS.

Intubation Algorithm
Although optimisation prior to PHEA should result in success, it is important to plan for failure from the outset. A shared mental model for the team and clearly defined actions in the case of failure, will reduce the risk of harm and improve the team response.

Use of a checklist prior to PHEA will both ensure you have the correct equipment and facilitate mental preparation. Briefing the failed airway drill is a key component of the GNAAS prehospital emergency anaesthesia checklist.

The Difficult Airway Society (DAS) produces guidelines for the management of the unanticipated difficult airway (2015). The DAS guidelines are designed for use in hospital elective anaesthesia, where waking the patient up is possible, however many of the principles and process of managing the difficult airway and failed intubation are applicable to prehospital emergency anaesthesia.

Airway management is described in four sequential stages from A to D with the main principle that oxygenation should be maintained as the priority.

Plan A: Laryngoscopy and successful Intubation
Properly prepared anaesthesia and laryngoscopy should result in a view of the larynx that allows successful intubation. Successful intubation should be confirmed with the presence of end tidal carbon dioxide on waveform capnography. Other signs of successful intubation include fogging of the tube, chest wall movements with ventilation and breath sounds audible on auscultation in both axillae with absence of sounds over the stomach.

If there is a poor initial view of the larynx then a second attempt should only occur after adjustments have been made in personnel, positioning or equipment to optimise the chance of success. This process should be quick and is referred to as the '*30 second drill*':

- Adjust laryngoscopist position
- Adjust patient position
- Suction
- Insert laryngoscope to maximum and slowly withdraw under vision
- BURP on cricoid cartilage
- Change laryngoscope blade size

If intubation is unsuccessful declare *Failed Intubation* and move on to Plan B.

Plan B: Maintain oxygenation and supraglottic airway insertion
Maintain oxygenation as the priority. Insert an appropriately sized iGel and ventilate. If ventilation is confirmed with end tidal carbon dioxide and is adequate, then the patient should be packaged and transported to hospital. The pre-alert should include reference to the difficult airway.

If unable to ventilate with the iGel, declare failure to the team and move to plan C.

Plan C: Maintain oxygenation and facemask ventilation
Apply facemask ventilation to maintain oxygenation. Use adjuncts such as an oropharyngeal airway (OPA) or nasopharyngeal airway (NPA), and two-handed technique to hold the mask. If ventilation is possible, then package the patient and transfer to hospital with a pre-alert.

If ventilation is not possible then declare can't intubate, can't oxygenate and move on to Plan D

Plan D: Emergency front of neck access
Emergency front of neck access (FONA) is a last-ditch attempt to maintain or restore oxygenation in the patient where all other methods to ventilate have failed. Oxygen should continue to be delivered via the upper airway.

DAS 2015

Failed intubation, failed oxygenation in the paralysed, anaesthetised patient

CALL FOR HELP

↓ Continue 100% O_2
Declare CICO

Plan D: Emergency front of neck access

Continue to give oxygen via upper airway
Ensure neuromuscular blockade
Position patient to extend neck

Scalpel cricothyroidotomy

Equipment:
1. Scalpel (number 10 blade)
2. Bougie
3. Tube (cuffed 6.0mm ID)

Laryngeal handshake to identify cricothyroid membrane

Palpable cricothyroid membrane
Transverse stab incision through cricothyroid membrane
Turn blade through 90° (sharp edge caudally)
Slide coude tip of bougie along blade into trachea
Railroad lubricated 6.0mm cuffed tracheal tube into trachea
Ventilate, inflate cuff and confirm position with capnography
Secure tube

Impalpable cricothyroid membrane
Make an 8-10cm vertical skin incision, caudad to cephalad
Use blunt dissection with fingers of both hands to separate tissues
Identify and stabilise the larynx
Proceed with technique for palpable cricothyroid membrane as above

Post-operative care and follow up
- Postpone surgery unless immediately life threatening
- Urgent surgical review of cricothyroidotomy site
- Document and follow up as in main flow chart

This flowchart forms part of the DAS Guidelines for unanticipated difficult intubation in adults 2015 and should be used in conjunction with the text.

Reproduced from -
Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. C. Frerk, V. S. Mitchell, A. F. McNarry, C. Mendonca, R. Bhagrath, A. Patel, E. P. O'Sullivan, N. M. Woodall and I. Ahmad, Difficult Airway Society intubation guidelines working group
British Journal of Anaesthesia, 115 (6): 827–848 (2015) doi:10.1093/bja/aev371

CHAPTER SEVEN

ADVERSE EVENTS

Changes in the patient or equipment are common in critically unwell ventilated patients, particularly in the context of the busy and unpredictable prehospital/transport environment and the changing physiology during the resuscitation of a critically unwell patient. There are two key phases to managing a critical change in the patient's physiology or ventilator mechanics, the first of which is prevention.

Ensure that you have checked your equipment and drugs prior to enplaning and that you have adequate supplies.

Early recognition and intervention of impending problems can save you and the patient a lot of hassle. Therefore, develop methods to ensure that you maintain situational awareness even in a moving vehicle/loud air platform. Adopt a method for packaging that allows you access to the monitoring, ET tube and piping and find a position where you can see the chest and airway at a minimum. Set the ventilator and monitor alarms to sensible limits; too wide and they don't go off and too tight and they go off all the time. If the alarms are going off all the time, then they will be ignored, the busier and more overloaded you are.

Check cards

GNAAS advocates for check cards following a standardised approach to address common problems. We use emergency action cards based on the Association of Anaethetists guidelines. Crucially these are sign/symptom based rather than diagnosis based.

These follow a common theme and order to enable easy use and a shared mental model.

1. Firstly, state the problem.

2. Assess for and manage critical features that are immediately life threatening.

3. Perform a systematic check of the entire system to identify the problem. Treat the identified problem. These cards are to assist with diagnosis expecting you to utilise the specific SOPs for treatment of the problem.

Example check card for Increased Airway Pressure

GREAT NORTH AIR AMBULANCE SERVICE

Emergency Action Card

Increased airway pressure

State out loud: "The patient has developed high airway pressures"

Action:

If critical features

Complete absence of chest movements?

Rapidly worsening hypoxia?

Immediately convert to manual ventilations via bag & 100% oxygen. Connect directly to the tracheal tube - **do not use** catheter mount or HME filter. Confirm whether the chest is rising and falling and get a manual 'feel' for the airway pressure

Check:

1 Adequate oxygen delivery

- Ensure ventilator is set to 100% oxygen. Confirm appropriate pressure alarm settings.
- Perform a visual inspection of entire breathing system from ventilator to endotracheal tube for blockages, kinking etc.

2 Airway

- Check position of endotracheal tube and exclude endobronchial migration
- Check capnograph presence and shape of the wave
- Consider passing a tracheal suction catheter to confirm tube patency and to clear secretions

3 Breathing

- Check chest movement symmetry and co-ordination with ventilator. Exclude patient pathology

Potential causes

- Kinking or intrinsic blockage within the breathing circuit, HME or endotracheal tube
- Endobronchial migration
- Inadequate neuromuscular blockade
- Bronchospasm/Anaphylaxis
- Secretions/Plugging/Pulmonary oedema/Pulmonary contusions/Foreign body
- Pneumothorax

Increased airway pressure

North Air Ambulance Service

Version 1 December 2020

Increased Airway Pressure

Critical features:

1. Complete absence of chest wall movement
2. Rapidly worsening hypoxaemia

Immediate management of critical features:

1. Connect to bag and 100% oxygen, mount directly on ET tube, do not include filter/catheter mount
2. Manually ventilate
3. Check for chest rise and get a 'feel' for inflation pressure

Check:

1. Adequate oxygen delivery
    a. Set to 100% oxygen. Confirm appropriate ventilator alarm settings
    b. Perform a visual inspection of the entire breathing circuit looking for kinking, blockages.
2. Airway
    a. Check the position of the endotracheal tube and ensure there has not been in recognised endobronchial migration.
    b. Confirm the presence of the capnograph trace. Look at the shape of the wave. A sloped wave may indicate bronchospasm, an early notch in the wave may indicate inadequate paralysis/sedation. This is further addressed at the end of the chapter.
    c. Consider passing a narrow bore suction tube to clear secretions and check for patency.
3. Breathing
    a. Check for chest movement symmetry.
    b. Consider and treat patient pathology like tension pneumothorax.

Potential causes:

1. Tension pneumothorax
2. Bronchospasm/Anaphylaxis
3. Inadequate neuromuscular blockade
4. Kinking it intrinsic blockage of the ETT, HME or breathing circuit.
5. Endobronchial migration
6. Secretions/plugging/pulmonary contusions

Hypotension

Critical features:

1. Loss of central pulse
2. Falling $ETCO_2$

Immediate management of critical features:

1. Consider low flow state or cardiac arrest; declare potential arrest
2. Immediate concurrent management of presumed causes e.g., Hypovolemia, tension pneumothorax
3. Consider vasopressors/volume replacement

Check

1. Airway/Breathing
   a. Check for bilateral chest wall movement
   b. Ensure ventilator is set to 100% oxygen
   c. Consider pneumothorax and treat
   d. Check CO2 trace
2. Circulation
   a. Check central and peripheral pulses/ECG
   b. Re-cycle blood pressure cuff
   c. Replace volume
   d. In trauma ensure bleeding is controlled
3. Anaesthetic
   a. Pause sedative infusions/Avoid further boluses
   b. If overzealous anaesthetic suspected give vasopressor

Potential causes:

1. Hypovolaemia – bleeding or sepsis
2. Overzealous sedation
3. Tension pneumothorax
4. Bradycardia
5. Myocardial – heart block
6. Anaphylaxis
7. Neurogenic

Beware that non-invasive blood pressure readings can be unreliable both in the context of vibrating transport platforms and shock. Be wary of disregarding low BP readings but also consider monitor error if other causes have been addressed or seem unlikely.

Hypoxia

Critical features:

1. Complete absence of chest wall movement
2. Loss of CO_2 trace

Immediate management of critical features:

1. Connect to bag and 100% oxygen, mount directly on ET tube, do not include filter/catheter mount
2. Manually ventilate
3. Check for bilateral chest rise

Check:

1. Adequate oxygen delivery
    a. Set to 100% oxygen
    b. Ensure capnography trace remains and that ETT is still in place/patent
2. Airway
    a. Check the position of the endotracheal tube and ensure there has not been unrecognised endobronchial migration.
    b. Confirm the presence of the capnograph trace. Look at the shape of the wave. A sloped wave may indicate bronchospasm, an early notch in the wave may indicate inadequate paralysis/sedation.
3. Breathing
    a. Check for chest movement symmetry.
    b. Consider and treat patient pathology like tension pneumothorax.
    c. Consider increasing the respiratory rate or PEEP
4. Circulation
    a. Check blood pressure and perfusion state, treat shock.
5. Equipment
    a. Check probe attached and no interference from movement/light sources

Potential causes:

1. Pneumothorax
2. Lung injury, aspiration, contusions, pneumonia
3. Poor perfusion, low BP, cold digits
4. Insufficient ventilation
5. Inadequate oxygen delivery
6. Bronchospasm
7. Secretions

Others

Low inflation pressures

This is generally a sign of circuit disconnection or leak although it can't find a disconnect ensure that the ventilator alarms are reasonable. As before if in doubt convert to a proximal bag and hand ventilate.

Hypertension

Hypertension may be associated with some pathologies (particularly intracerebral bleeding) or anaesthetic agents. However, it is important to consider inadequate anaesthesia especially in the presence of a tachycardia or dilated pupils. Remember that most sedation agents take a reasonably long onset time.