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INSTITUTE OF
TRAUMA AND INJURY
MANAGEMENT



The NSW Institute of Trauma and Injury Management in
Conjunction with the Trauma Department, Liverpool Hospital

ADULT TRAUMA CLINICAL PRACTICE GUIDELINES

Emergency Airway Management in the Trauma Patient



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Important Note

“Emergency Airway Management in the Trauma Patient” clinical practice guidelines are aimed at assisting clinicians in informed medical decision-making. They are not intended to replace decision-making. The authors appreciate the heterogeneity of the patient population and the signs and symptoms they may present with and the need to often modify management in light of a patient’s co-morbidities.

The guidelines are intended to provide a general guide to the management of specified injuries. The guidelines are not a definitive statement on the correct procedures, rather they constitute a general guide to be followed subject to the clinicians judgement in each case.

The information provided is based on the best available information at the time of writing, which is December 2003. These guidelines will therefore be updated every 5 years and consider new evidence as it becomes available.

These guidelines are intended for the use in adults only.

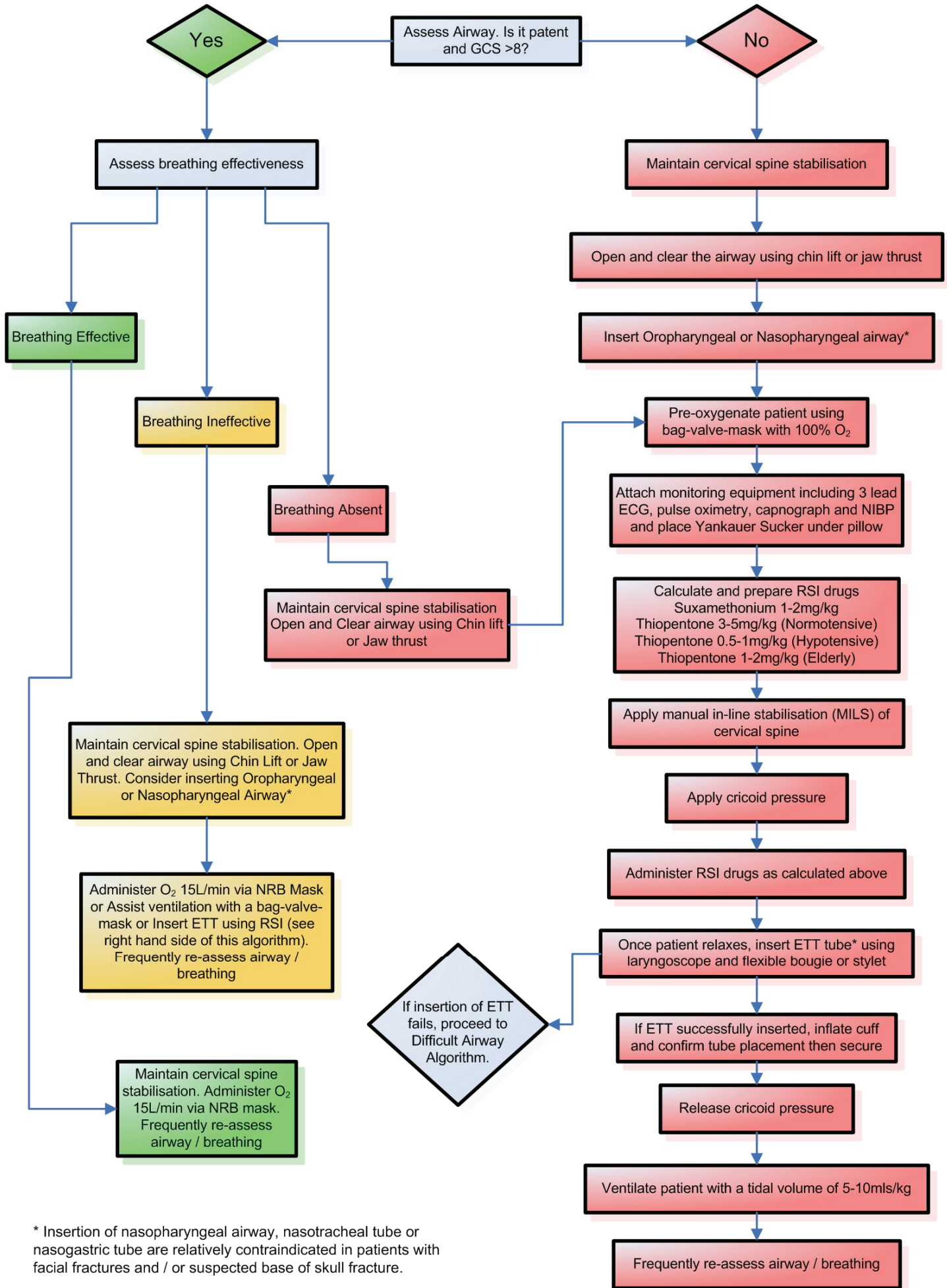
All guidelines regarding pre-hospital care should be read and considered in conjunction with NSW Ambulance Service protocols.

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Algorithm 1:

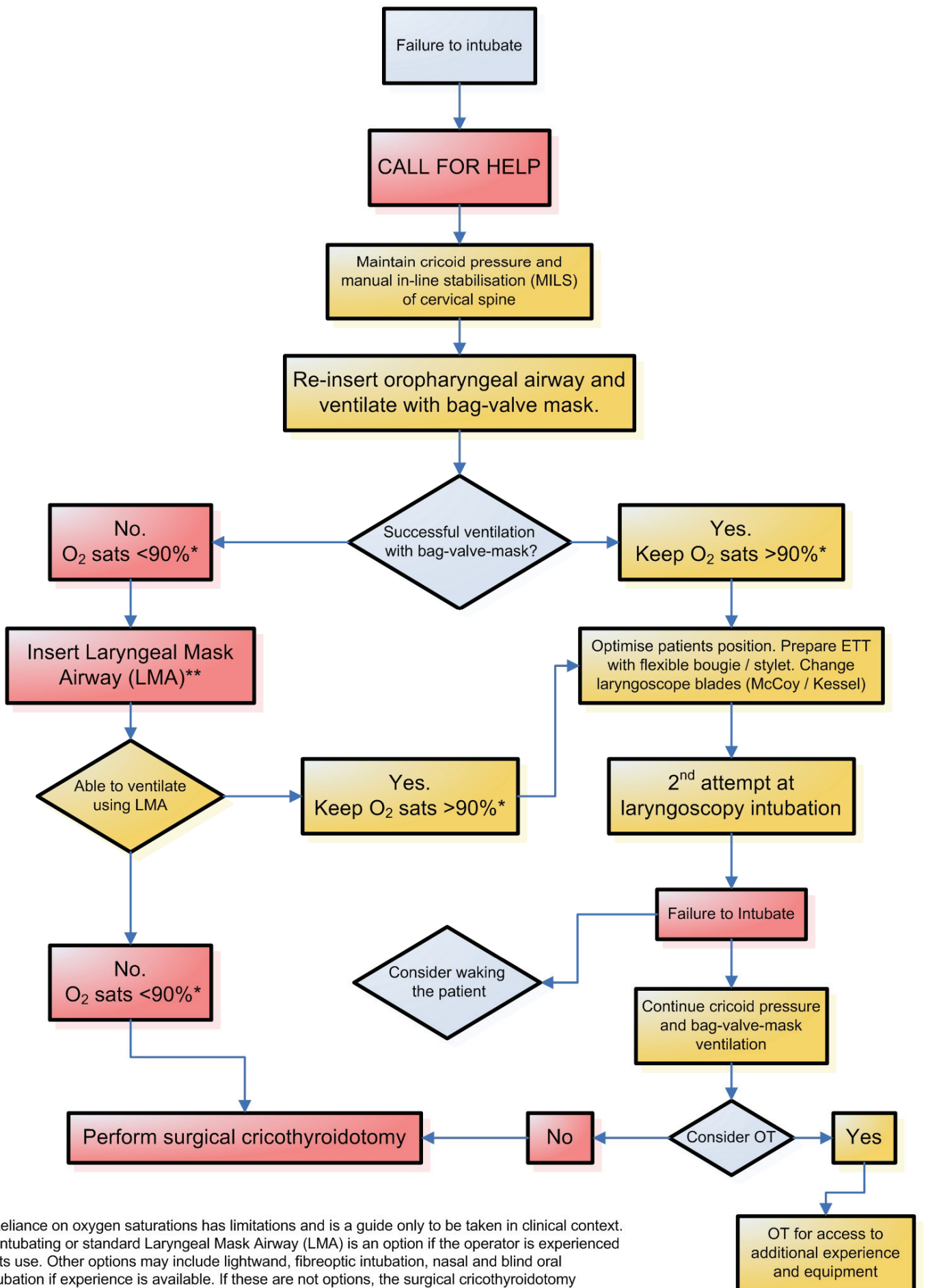
Airway Management



* Insertion of nasopharyngeal airway, nasotracheal tube or nasogastric tube are relatively contraindicated in patients with facial fractures and / or suspected base of skull fracture.

Algorithm 2:

Difficult Airway Management



* Reliance on oxygen saturations has limitations and is a guide only to be taken in clinical context.
** Intubating or standard Laryngeal Mask Airway (LMA) is an option if the operator is experienced in its use. Other options may include lightwand, fiberoptic intubation, nasal and blind oral intubation if experience is available. If these are not options, the surgical cricothyroidotomy should be performed immediately.

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Summary of Guidelines

In the patient with potential cervical spine injury requiring emergency intubation in the resuscitation room, what is the optimal method of achieving a secure airway?

GUIDELINE	Level Of Evidence
Rapid sequence induction and intubation (RSI) is the stepwise process to be undertaken for the intubation of this group of patients (see appendix A for description of RSI). Oral endotracheal intubation is the technique of choice.	Consensus
Patients stable enough to move to the operating theatre for intubation may have alternative options for achieving a secure airway including awake intubation.	Consensus
It is recommended that a tracheal tube introducer (i.e. flexible bougie or stylet) is immediately to hand whenever RSI is undertaken. The tracheal tube introducer should be considered for routine, first-line use in all cases to maximise rates of intubation on first attempt (19).	II

In adults with severe head injury (GCS \leq 8) undergoing emergency intubation in the ED, what are the optimal induction agents to minimise secondary brain injury?

GUIDELINE	Level Of Evidence
Emergency department intubation in the severely head injured adult should be with: <ul style="list-style-type: none"> • suxamethonium 1-2mg/kg (57;58) • thiopentone 3-5mg/kg if normotensive 	II Consensus
There is no evidence to support the use of lignocaine or other adjuncts (59).	I

In hypotensive trauma adults requiring emergency intubation in the ED, what is the optimal induction technique to minimise further haemodynamic instability?

GUIDELINE	Level Of Evidence
<p>Thiopentone should be first-line choice of anaesthetic agent. Other options may include ketamine and etomidate but emphasis is given to the requirement for experience in their pharmacodynamic profiles before use. It is recommended that propofol should be avoided in this group of patients. Doses in Table 4.</p>	<p>Consensus</p>
<p>A fluid bolus should be administered at the time of induction to attenuate further haemodynamic compromise. Vasopressors are recommended second line to support the uncompensated hypotensive trauma patient. Recommended direct alpha agonists are phenylephrine or metaraminol in incremental boluses.</p>	<p>Consensus</p>

In the trauma adult requiring emergency control of the airway, what is the best treatment algorithm to follow for management of a “difficult airway”?

GUIDELINE	Level Of Evidence
<p>Management of adults with Difficult Airways should be as per Algorithm 2 at the front of this guideline.</p>	<p>Consensus</p>

Preamble- Basic Airway Management

Before proceeding to read this document it is important that clinicians appreciate the importance of basic airway principles in the assessment and management of trauma patients. It is also equally important that clinicians recognise their own limitations and call for help from experienced airway operators early. Having good basic airway management skills teamed with experience facilitates a safe and successful approach to airway management.

Prevention of hypoxia by maintaining a patent, protected airway with adequate ventilation takes priority over all other conditions the trauma clinician has to manage. Cervical spine stabilisation and immobilisation must be ensured by in-line immobilisation at all times.

Early recognition and appropriate management of the injured patient's airway and ventilation will avoid preventable deaths from airway problems after trauma. Initial assessment and management of the airway and ventilation in the injured adult is outlined below. Assessment of life threatening injuries is done simultaneously with the immediate institution of life saving interventions. Please see Algorithm 1 at the front of this guideline.

1. Airway Assessment

- Look to see if the patient is agitated, obtunded or cyanosed. Also look for accessory muscle use and retractions. Assess for deformity from maxillofacial, neck or tracheal trauma and airway debris such as blood, vomitus and loose teeth.
- Listen for abnormal breathing sounds eg snoring, gurgling, stridor and hoarseness.
- Palpate the trachea to ascertain whether it is deviated from the midline.
- Consider the likelihood of encountering a difficult airway at intubation eg small chin, protruding dentition, large body habitus, facial hair, pregnancy.

2. Airway Management

Basic airway maintenance techniques:

- Tongue and soft tissue obstruction of the hypopharynx in the unconscious patient can be corrected by the chin lift or jaw thrust manoeuvre.
- Suction the airway with a rigid suction device to remove any blood, vomitus or debris.
- Insert an oropharyngeal or nasopharyngeal airway insertion to maintain a patent airway (nasopharyngeal airway insertion is contraindicated in patient's with suspected base of skull fractures)

A definitive airway is defined as a cuffed tube secured in the trachea. This is required if:

- the patient is apneic
- inability to maintain a patent airway using the basic airway maintenance techniques described above
- risk of aspiration of blood or vomit
- impending or potential airway compromise
- Closed head injury with GCS \leq 8
- Inability to maintain adequate oxygenation with a face mask.

Definitive airway interventions include:

- Orotracheal tube insertion
- Nasotracheal tube insertion
- Surgical airway (surgical cricothyroidotomy)

3. Ventilation Assessment

- Look for a symmetrical rise and fall of the chest. Asymmetry may suggest a flail chest or splinting.
- Listen for equal air entry on both sides of the chest.
- Feel the chest for injuries and percuss the chest for evidence of pneumothorax or haemopneumothorax.
- Adjuncts may include pulse oximetry, arterial blood gas and chest x-ray.

4. Ventilation Management

- Supplemental oxygen is to be delivered to all trauma patients. If the patient is not intubated, deliver the oxygen via a high flow oxygen mask or bag-valve-mask device.
- If the patient is intubated, a volume or pressure regulated ventilator should be used if available.
- If a tension pneumothorax is suspected, an immediate needle decompression of the effected side is required.

5. Reassessment

- Both airway patency and ventilation adequacy require frequent re-assessment in the trauma patient, especially if the patient does not have a definitive airway.

1. Introduction

Hypoxia and airway compromise are recognised to be significant contributing factors in up to 34% of deaths pre-hospital. (1) The compromised airway after trauma places the patient at risk of hypoxia and hypercarbia. Hypoxia rapidly results in end-organ damage and cardiac arrest; hypercarbia precipitates cerebral vasodilatation, respiratory acidosis and a reduced level of consciousness. Aspiration of gastric contents and the subsequent lung injury are independent factors increasing morbidity and mortality in this group of patients. (2;3)

Issues in the trauma patient influencing oxygenation include airway obstruction, hypoventilation, associated lung injury, pre-morbid cardio-respiratory status and reduced laryngeal reflexes precipitating the risk of aspiration of gastric contents. Airway obstruction and hypoventilation are issues particularly associated with a reduced level of consciousness, facial burns and severe maxillofacial trauma. Hypovolaemia results in reduced oxygen-carrying capability, reduced tissue perfusion and subsequent tissue hypoxia. Previous reviews of the scientific literature have identified the key indications to intubate a trauma patient. (4) These include any cause of inadequate ventilation or oxygenation as listed above; in addition, intubation of the confused, non-compliant patient with cerebral hypoxia or under the influence of drugs or alcohol may be required in order to facilitate resuscitation attempts.

Studies have shown that 9-28% of trauma patients require intubation. (4-7) Complications may arise as a result of emergency intubations (4;5;8-10;10;11) but failure or delay in securing an adequate airway causes unacceptably high morbidity and mortality rates (12-14).

Different clinical scenarios may warrant a different approach to intubation particularly with respect to the induction agents employed and the adjuncts used. It is recognised that the equipment employed, methods used and induction agents selected vary greatly between any one emergency department (ED) and between hospitals on an international scale.

2. Methods

2.1 Scope of the guidelines

The guidelines are intended for use by all clinicians involved in airway management of trauma patients presenting to the ED. Extrapolation to other clinical situations such as the operating theatre and pre-hospital environment may be relevant but has not been specifically evaluated in this search.

These guidelines are not prescriptive and not produced as rigid procedural paths. Clinicians must assess each patient on individual merit which, together with consideration of their own skill level and experience will enable them to use these evidence-based recommendations in providing optimal patient care.

It is recognised that the guidelines may not suit all patients in all clinical situations. The guidelines rely on individual clinicians to decipher the needs of individuals. They aim to provide information on what decisions can be made, rather than dictate what decisions should be made.

2.2 Aims and Objectives of the guideline

We set out to produce practical evidence-based guidelines for airway management in common scenarios of trauma resuscitation.

The objectives of this study were to develop practical, evidence-based guidelines for management of the emergency airway in the acute resuscitation phase of trauma patient management based on the key clinical questions listed below.

1. In the adult with potential cervical spine injury requiring emergency intubation in the resuscitation room, what is the optimal method of achieving a secure airway?
2. In adults with severe head injury (GCS \leq 8) undergoing emergency intubation in the ED, what are the optimal anaesthetic agents to minimise secondary brain injury?
3. In hypotensive trauma adults requiring emergency intubation in the ED, what is the optimal induction technique to minimise further haemodynamic instability?
4. In the trauma patient requiring emergency control of the airway, what is the best treatment algorithm to follow for management of a “difficult airway”?

2.3 Literature Review

A full literature search was undertaken for relevant articles in MEDLINE (1966 to 2003, EMBASE (1980 to 2003) and the Cochrane Central Register of Controlled Trials. Relevant articles relating to adults and written in English language were appraised. English language abstracts of foreign articles were included. Full list of search terms used are listed in Appendix A.

Relevant studies were obtained and their references hand searched for inclusion.

2.3.1 Inclusion & Exclusion criteria

✓ Inclusion Criteria

Meta-analysis, Controlled Clinical Trials, Case Series
Aged > 16 years

X Exclusion Criteria

Case Reports, Editorials
Aged \leq 16 years

Non-trauma articles examining rapid sequence induction and intubation were included for consideration in the absence of trauma specific research. The limitations of this data is recognised and was used only by the working party to assist in the development of consensus guidelines.

2.4 Assessment of the evidence for strength, size and relevance

Recommendations were formed, and guidelines produced based on the best available evidence and consensus opinion based on interpretation of the evidence found.

2.4.1 Strength

Level

The articles were classified according to their general purpose and study type. From this each article was allocated a Level of Evidence as outlined by the Australian National Health and Medical Research Council (NHMRC) (15):

Level I	Evidence obtained from a systematic review of all relevant randomised control trials
Level II	Evidence obtained from at least one properly-designed randomised control trial
Level III-1	Evidence obtained from well-designed pseudo-randomised controlled trials (alternate allocation or some other method)
Level III-2	Evidence obtained from comparative studies (including systematic reviews of such studies) with concurrent controls and allocation not randomised, cohort studies, case-control studies, or interrupted time series with a control group
Level III-3	Evidence obtained from comparative studies with historical control, two or more single arm studies or interrupted time series without a parallel control group
Level IV	Evidence obtained from a case-series, either post-test or pre-test/post-test

Table 1: Levels of Evidence - NHMRC

Quality

Selected articles were appraised according to the NHMRC. The MERGE assessment tool (16) was used to rate the articles for quality on a 4-point scale as follows:

Low risk of bias	A	All or most evaluation criteria from the checklist are fulfilled, the conclusions of the study or review are unlikely to alter
Low-moderate risk of bias	B1	Some evaluation criteria from the checklist are fulfilled. Where evaluation criteria are not fulfilled or are not adequately described, the conclusions of the study or review are thought unlikely to alter
Moderate-High risk of bias	B2	Some evaluation criteria from the checklist are fulfilled. Where evaluation criteria are not fulfilled or are not adequately described, the conclusions of the study or review are thought likely alter.
High risk of bias	C	Few or no evaluation criteria fulfilled. Where evaluation criteria are not fulfilled or adequately described, the conclusion of the study or review are thought very likely to alter.

Table 2: Codes for the overall assessment quality of study checklists

2.5 Consultation Processes

A working group was established prior to the onset of the study represented by all specialities likely to be affected by the guidelines. Specialists from backgrounds of anaesthesia, trauma, intensive care, pre-hospital retrieval teams and the emergency department were involved; both rural communities and teaching hospital environments were represented. All clinicians were extremely experienced in their field of practice with a special interest in trauma care.

The working group considered common situations in the resuscitation of the trauma patient and developed four clinical questions on which to base these guidelines.

The joint expertise and experience of the Trauma Airway Management Working Group provided consensus opinion on the findings of the literature searches in order to produce guidelines, recommendations or options based on this literature. For purposes of validation, 10% of the appraised articles identified by the literature search were re-assessed by members of the working group to ensure consistency of opinion on the appraisal. Recommendations were graded depending on the level and quality of the evidence. They take into account the volume of evidence, applicability, generalisability to the target population, consistency of results and the potential clinical impact of guideline implementation (17). The implementation of these recommendations will be evaluated to ensure best practice (18).

The guidelines will be continually assessed and improved according to their degree of usefulness to clinicians, affects on patient outcomes and to keep current with scientific evidence.

2.6 Glossary

Hypotensive Patient - a systolic blood pressure (SBP) of less than 90 mmHg in adults and <100mmHg in adults over 55 years.

RSI - Rapid Sequence Induction

MILS - Manual in-line stabilisation

BURP - Backwards, Upward, right pressure to the thyroid cartilage to facilitate laryngeal views

3. In the patient with potential cervical spine injury requiring emergency intubation in the resuscitation room, what is the optimal method of achieving a secure airway?

GUIDELINE	Level Of Evidence
Rapid sequence induction and intubation (RSI) is the stepwise process to be undertaken for the intubation of this group of patients (see appendix A for description of RSI). Oral endotracheal intubation is the technique of choice.	Consensus
Patients stable enough to move to the operating theatre for intubation may have alternative options for achieving a secure airway including awake intubation.	Consensus
It is recommended that a tracheal tube introducer (i.e. flexible bougie or stylet) is immediately to hand whenever RSI is undertaken. The tracheal tube introducer should be considered for routine, first-line use in all cases to maximise rates of intubation on first attempt (19).	II

3.1 Scientific Evidence

RSI has become the standard practice for intubating the trauma patient at risk of a cervical spine injury. Under the search strategy employed looking at emergency intubations in trauma patients there were no level I or II evidence to support this technique. Much of the work to enforce RSI as the technique of choice has been in fields other than trauma such as obstetrics. The generalisability of this data to the trauma patient is unknown.

(a) Immobilising the cervical spine during intubation.

Several studies have assessed the best way to minimise movement in the cervical spine during airway management (20-24). The best method for immobilising the c-spine is dependant on minimising movement of the spine whilst allowing adequate view of the laryngeal aperture to facilitate a safe and efficient intubation. When considering the degree of c-spine movement in most studies it is notable that there is no definition of what is a 'safe' amount of movement.

In a non-randomised trial, Heath and colleagues (22) evaluated the effect of rigid cervical collar, tape across the forehead and sandbags either side of the neck and manual-in-line immobilisation on view on laryngoscopy. He found that there was a poor view on laryngoscopy (grade 3 or 4) in 64% of patients when immobilised in a collar, tape and sandbags compared to 22% undergoing manual in-line stabilisation (MILS) ($P < 0.001$).

MILS was found by Majernick (23) to allow the least movement during intubation. In a cadaver model, MILS was also found to result in less cervical subluxation and allow better vocal cord visualisation when compared to immobilisation in a rigid cervical collar (21). MILS however, although superior to other methods of immobilisation, was found by Nolan to reduce the view of the larynx by 45% and in 22% of patients nothing was visible beyond the epiglottis (19).

(b) Method of securing the airway

The best method for securing the airway in the trauma patient at risk of a cervical injury should minimise c-spine movement, be safe and appropriate to the Emergency Department setting.

(i) Degree of cervical spine movement associated with securing an airway

Brimbacombe (20) found in the patient with potential spinal injury, fiberscope-guided nasotracheal intubation exhibited the least amount of cervical motion. These findings however were not replicated in Donaldson's study who found no advantage of nasal intubation over oral tracheal intubation in terms of cervical movement (25). The use and practice of fiberscope-guided nasotracheal intubation in the emergency department however, in most institutions, is not feasible due to unavailability of fiberoptic equipment in emergent situations and practitioners experienced in its use.

The laryngeal mask, although comparable to oral-tracheal intubation in terms of success and time to placement, was found by Keller to cause greater posterior displacement of the cervical vertebrae when compared to oral-tracheal intubation (pressure maximum during laryngoscope and fiberscope-guided oral tracheal intubation was zero in all patients vs 43cmH₂O for LMA insertion).(26) Brimacombe, using cadavers however found laryngeal mask insertion resulted in similar displacement of the cervical vertebrae as oral-tracheal intubation (1.7 +/- 1.3 mm for LMA vs 2.6 +/- 1.6 mm for oral intubation). (20) There are several differences in these studies that may explain the conflicting results. Keller used microchip pressure sensors to measure the effect of airway manoeuvres of the cervical vertebrae in the presence of an intact spine, whilst Brimacombe used continuous lateral fluoroscopy measuring actual movement of the vertebrae in the presence of a posteriorly destabilized third cervical vertebra.

Watts (27) compared the affect of the Macintosh laryngoscope blade to the Bullard laryngoscope on cervical spine extension. The Bullard laryngoscope with MILS insitu resulted in less cervical spine extension (5.6 +/- 1.5 degrees) when compared to Macintosh blade (12.9 +/- 2.1 degrees). However, the time taken to intubate with the Bullard laryngoscope were longer (20.3 +/- 12.8 s vs 40.3 +/- 19.5 s; P < 0.05). The Bullard laryngoscope may be of benefit when the need for intubation is not time critical (32). Studies evaluating the McCoy laryngoscope on cervical extension have been conflicting (28;29).

(ii) Safety

Brimbacombe reported a 95% success rate with oral tracheal intubation with MILS insitu in a healthy patient population (30). Smith (31) found tracheal intubation using fiberoptic laryngoscope was associated with lower intubation difficulty and better views of the laryngeal structures when compared to conventional laryngoscopy. However, the use of fiberoptic laryngoscope did not equate to a better success rate or less number of attempts.

Nolan in a randomised trial, found the gum elastic bougie in patients with suspected c-spine injury useful in facilitating intubation when the glottis is not immediately visible. Using the gum elastic bougie resulted in successful intubation in the intervention group as well as five patients who failed intubation using standard laryngoscopy. Time taken to intubate using the gum elastic bougie did not exceed 45 seconds (median 25 seconds, comparable to the visual intubation group (maximum 45 seconds, median 20 seconds) (19).

The laryngeal mask has proven usefulness as an airway in fasting patients undergoing anaesthesia however, its role in management of the difficult airway and the traumatic airway is still evolving. The laryngeal mask airway (LMA) does not reliably protect against aspiration and may exert greater pressure against the cervical vertebrae than established intubation techniques. The LMA is not recommended for first-line management of the airway in trauma patients, but its use as emergent airway when conventional techniques fail has been established and accepted as a standard of care (32).

(iii) Appropriateness to the Emergency Department

Many of the studies evaluating intubation techniques take place in cadaver models or in the operating theatre in non-trauma patients mimicking trauma scenarios (for example obstetric patients with cervical immobilisation). There was one study identified that evaluated rapid sequence induction (with the application of cricoid pressure and MILS) undertaken by Emergency physicians in patients with spinal injuries requiring emergent intubation. 73 patients were intubated orally. Neurological assessment was compared before and after RSI. There were no neurological sequelae in these patients (95% CI 0-4%) (33).

A larger prospective review of 610 emergency department intubations was undertaken by Sakles (11), of which trauma patients accounted for 47.7%. 89.9% of patients underwent RSI (n=515, in whom 99.2% were successfully intubated). Intubations where paralytic agents were not given resulted in a 91.5% success rate. There was a reported complication rate of 9.3%. The most common complication was desaturation ($\text{SaO}_2 < 85\%$; 3.2%, but did not result in any neurological deficit at discharge. Second most common complication was right main stem intubation (3.0%, none resulting in further complications (11). This review suggests that RSI is safe and associated with a small number of complications in the emergency department.

3.2 Discussion

There is a 2-5% risk of injury to the c-spine in trauma patients (33-38) of which up to 14% will be unstable (39;40). Criswell found 10% of blunt trauma patients with proven c-spine injury needed emergency intubation within 30 minutes of arrival in the emergency department (ED) and 26% within 24 hours of admission (33). At the time of emergency intubation, the injury must often be presumed based on clinical signs and mechanism of injury; further investigation in the form of plain radiographs, computerised tomography and magnetic resonance imaging will provide detailed information in due course.

Advanced Trauma Life Support (ATLS) courses teach the first priority of trauma patient management is airway control with c-spine immobilisation. (41) Rapid intubation when appropriate will therefore be complicated by the need to minimise any movement of the c-spine and to be aware of associated risks of the procedure. (42;43)

In trauma patients undergoing emergency intubation in the ED, the aim is to immobilise the c-spine whilst ensuring optimal conditions for effective intubation and minimising complications. The use of MILS is recommended to immobilise the c-spine. This entails firmly holding the patient either side of the head with the neck in the midline and the head on a firm trolley surface. Traction is not applied. The aim is to prevent any flexion or rotation of the c-spine when laryngoscopy is performed. To assist the airway clinician, the assistant needs to crouch by the trolley, slightly to one side whilst intubation is performed

(Figure 2). The cervical collar may be loosened or the anterior portion temporarily removed to allow mouth opening and the application of cricoid pressure. (33;44;45)

The working party agreed that RSI involves four experienced personnel with dedicated roles. Compromise on this will increase the chance of complications. Roles include i) the airway clinician to intubate the patient, ii) an assistant placed to his/ her left hand side, at the head of the bed to provide MILS, iii) a second assistant to provide cricoid pressure with their right hand and assist the clinician with equipment from the patient's right-hand side, iv) a third assistant to administer intravenous induction agents.

Basic physiological monitoring should not be a compromise from requirements elsewhere in the hospital (Table 3) and confirmation of correct tube placement should include the measures described at Appendix B.

Heart rate Non-invasive blood pressure Cardiac monitor (ECG) Pulse oximetry Capnography

Table 3: Minimal monitoring requirements for RSI

A selection of laryngoscope blades should also be available both in size and design. The volume of evidence in trauma is limited but both the MacIntosh curved blade and the McCoy blade have some evidence to suggest they may assist in intubation in this population (28;29;46).

The laryngeal mask airway (LMA) is a simple effective airway device (47). It requires some training before use but has some indications for use in patients with potential c-spine injury as a temporary adjunct when endotracheal tube insertion fails (see Algorithm 2 - Difficult Airway Management).

3.3 Conclusion

There is a paucity of evidence pertaining to the management of the airway in trauma patients. The data available was teamed with professional opinion in most instances.

There are clinical implications in the resources required as a result of this recommendation. RSI requires at least 4 people and may take some minutes to complete at a time when concurrent activity in the resuscitation is most urgent. The described technique ensures a speedy, safe intubation and sufficient staffing levels should be routinely maintained in any department receiving trauma patients.

4. In adults with severe head injury (GCS ≤ 8) undergoing emergency intubation in the ED, what are the optimal induction agents to minimise secondary brain injury?

GUIDELINE	Level Of Evidence
Emergency department intubation in the severely head injured adult should be with: <ul style="list-style-type: none"> • suxamethonium 1-2mg/kg (57;58) • thiopentone 3-5mg/kg if normotensive 	II Consensus
There is no evidence to support the use of lignocaine or other adjuncts (59).	I

4.1 Scientific Evidence

Recent studies have looked at the scientific evidence to determine the requirement for intubation in trauma patients with severe cognitive impairment (GCS ≤ 8). RSI is the commonly accepted sequence of events leading to endotracheal intubation in the emergency setting (60;61) as described in the previous chapter. The drugs used to facilitate this process are varied and evidence for the optimal agents employed has not been consolidated to this time.

A number of studies have looked at modifications to RSI using Lignocaine (59;62-67), beta-blockers (62;66), and opiates (68-73) to attenuate the haemodynamic response and subsequent effects of laryngoscopy and intubation on intracranial pressure (ICP). However, few studies are designed to directly answer our clinical question and the limitations to conducting clinical research in the emergency setting are recognised.

(a) Neuromuscular blockade

There were no papers identified that directly answered the clinical question. Requirements for RSI demand the neuromuscular blocking agent to be fast acting with a short half-life and minimal side effects in particular with respect to haemodynamic and ICP changes (57;74). The evidence indicates that neuromuscular blockade does appear to attenuate ICP. The principle competing agents in the literature are suxamethonium (succinylcholine) and rocuronium.

(i) Effectiveness

A meta-analysis undertaken by Perry (75) compared rocuronium to succinylcholine during RSI. The paper concludes that succinylcholine creates excellent intubation conditions more reliably than rocuronium (RR 0.87 95% CI 0.81, 0.94) and should still be used as a first line muscle relaxant for rapid sequence induction intubations. Most of the studies included in this review, however include solely patients admitted for elective surgery, the effects on intracranial pressure are not examined in this paper.

In a randomised trial comparing rocuronium, succinylcholine and vecuronium found that there was a longer onset time for the rocuronium and vecuronium group when compared to succinylcholine (89secs rocuronium vs 144secs vecuronium vs 50 secs succinylcholine). The onset of action for rocuronium appeared to be dose related. The larger the dose the

quicker its onset time. The two larger doses of rocuronium had a similar time to action as that of succinylcholine, but resulted in significantly longer duration of action (58).

(ii) Effect on intra-cranial pressure

Koenig (57) undertook a randomised double blind control trial to evaluate whether fasciculations during rapid-sequence intubation lead to increased intracranial pressure and emesis with aspiration in head injured patients requiring intubation. To test this, patients received either a mini-dose of succinylcholine (0.1 mg/kg) or pancuronium (0.03 mg/kg) IV one minute prior to the full paralytic dose of succinylcholine (1.5 mg/kg) IV. There was no difference in fasciculations between the two groups, with authors concluding that succinylcholine is safe to use as the sole paralytic agent (57).

(a) Anaesthesia

Laryngeal instrumentation and endotracheal intubation are associated with a marked, transient rise in intracranial pressure. The optimal induction agent to attenuate these changes is poorly examined in the literature. Most studies pertaining to sedation and their affect on intracranial pressure have been tested during endotracheal suctioning or during intubation for non-traumatic neurosurgery.

Giffin and colleagues (76) examined the affect of thiopentone or midazolam on ICP, mean arterial pressure (MAP) and heart rate (HR) for induction of patients undergoing surgery for brain tumours. They found no difference between the two drugs and neither drug abolished the ICP rise associated with laryngoscopy or intubation.

The effects of morphine, fentanyl and sufentanil have been evaluated in head injured patients that have already undergone intubation. All three drugs were associated with an increase in ICP and decrease in MAP. These effects have been demonstrated in two randomised trials (72;73).

(b) Adjuncts

A systematic review undertaken by Robinson (59) to determine if pre-treatment with lignocaine improves neurological outcome in patients with head injury undergoing RSI could not find any evidence from which to draw a conclusion. A randomised trial published after this review evaluated the affect of esmolol or lignocaine on preventing a detrimental rise in HR and blood pressure (BP) during intubation of patients with isolated head trauma. This study found that both these drugs similarly attenuate the haemodynamic response (62). Neurological outcome was not measured in this study.

4.2 Discussion

Normal cerebral autoregulation is altered after head injury. The relationship between cerebral blood flow (CBF, MAP, cerebral perfusion pressure and ICP is disrupted maximally in the first 24 hours. During this initial period, CBF has been shown to be less than half that of normal individuals, significantly increasing the risk of cerebral ischaemia (77;78). The cranial vault may be viewed simplistically as a closed box containing brain tissue (85%, blood (5%) and cerebrospinal fluid (CSF) (10%). After traumatic brain injury the volume within the intracranial compartment increases due to tissue oedema and intracranial bleeding. Small changes in volume can be compensated by shift of CSF and blood flow but this is limited and further changes result in a steep rise in ICP. Increasing ICP will reduce cerebral perfusion resulting in cerebral ischaemia, neuronal injury and

further cerebral oedema. Cerebral perfusion pressures of <50mmHg are associated with reduced CBF and ischaemic injury (51,52). Exact targets are controversial but the Brain Trauma Foundation Guidelines recommend maintaining a MAP>90mmHg correlating to a CPP >70mmHg (79;80).

Prevention of secondary brain injury by close control of blood pressure and oxygenation has been shown to have enormous impact on patient outcome (77;78;81). Secondary brain injury is the damage to neurones after the initial impact of injury, due to the systemic physiological response to the initial injury. This is exacerbated by hypoxia and under-perfusion of tissues secondary to hypotension. Cascades of biochemical substances such as cytokines, glutamate and free radicals are believed to be the mediators of secondary brain injury. Recognition of this phenomenon has provided the basis for current guidelines on the management of the severely head injured patient (51-53;(79;82;83). Laryngoscopy and intubation result in a rise in HR, MAP and a surge in catecholamines (84;85) shown to be further exacerbated when rapid sequence induction is used (86). The details of the mechanism by which the ICP is increased is not known.

Pharmacological agents may be partially responsible and a number of studies have looked at modifications to RSI using Lignocaine, beta-blockers and opiates to attenuate the haemodynamic response and subsequent effects on the ICP. However, results of these studies are inconclusive or conflicting (59;62-64;66;74) not allowing a recommendation for their use at this time.

There are limitations to extrapolation of the available evidence. Firstly, there is unknown correlation of physiology between the acute head injured patient, a similar patient hours or days after admission, and non-trauma neurosurgical patients. Secondly, most studies compare induction agents and adjuncts during tracheal suctioning or elective intubation in lieu of RSI. Again, no direct correlation of the relationship between these interventions has been identified. Thirdly, correlation between brief changes in haemodynamics and ICP at induction has not been connected to any exacerbation of secondary brain injury nor overall clinical outcome. Finally, most studies are conducted with very small numbers reducing the power of conclusions drawn.

Factors to be considered in agent selection include rapidity of onset for use in RSI, simplicity of use, knowledge of side effects and experience in the mechanism of action of the individual agent. Thiopentone appears to have the greater effect on ICP. It increases cerebrovascular resistance, reduces CBF and reduces cerebral metabolic demand so having a specific cerebrally protective role. However the clinician should be mindful of the haemodynamic affects and prepare accordingly (87;88). There was no evidence evaluating the effect of propofol in rapid sequence induction of head injured patients in the emergency department. Consensus of opinions expressed some concern regarding its use due to the hypotensive inducing effects of propofol, recommending it should only be considered for use in RSI by clinicians experienced in its use. There was no evidence to support the preferential use of any other induction agent in this group of patients. Doses are considered in Table 4.

Table 4: Suggested drug dosage in trauma

Neuromuscular blockade:		
	Suxamethonium	1-2 mg/kg
	Rocuronium	0.5 mg/kg
Sedation:		
(a) Normotensive patient	Thiopentone	3-5 mg/kg
	Propofol	1-2 mg/kg
(b) Elderly patients*	Thiopentone	1-2 mg/kg
	Propofol	1 mg/kg (consider avoiding use)
<i>Ketamine (1 mg/kg) or Etomidate may be options in some institutions</i>		
(c) Hypotensive patient**	Thiopentone	0.5-1 mg/kg
	Propofol	Avoid
<i>Ketamine (0.5-0.75 mg/kg, Fentanyl (2 mcg/kg) or Etomidate may be options in some institutions</i>		

*Young patients with the potential for instability, eg recognised bleed despite normal haemodynamics, may fit into this category.

** Elderly with the potential for instability, eg recognised bleed despite normal haemodynamics, may fit into this category

Evidence for suxamethonium causing a raised ICP and for any benefit of rocuronium in RSI is inconsistent. Evidence seems weighted towards the use of suxamethonium as first line neuromuscular blockade with rocuronium a second option in RSI of severely head injured patients.

The use of adjunctive agents in preventing haemodynamic changes in response to laryngoscopy and intubation have been examined in the literature, but not extensively in the trauma and resuscitation setting. With respect to short-acting opiates such as fentanyl and sufentanyl, studies demonstrate a fairly consistent attenuation of haemodynamics (62;66;74). Changes in ICP and impact on neurological outcome are not adequately investigated.

Lignocaine is thought to have a neurone membrane stabilising effect inhibiting the release of excitatory neuroamines such as glutamate and reducing cerebral metabolic rate (89). The use of lignocaine prior to intubation has not been properly evaluated, and in the absence of this evidence, a recommendation for its use is difficult to justify. No evidence for the use of lignocaine, opiate or other adjunct was found.

No studies were identified to exclude patients with GCS 3 and absent laryngeal reflexes from induction with intravenous agents as described.

4.3 Conclusion

In the patient with severe head injury, awareness of adverse changes in intracranial pressure (ICP) will influence the method of induction employed. (90) Endotracheal stimulation and the pharmacological agents used both adversely affect the ICP. (87;91;92) Prevention of cerebral ischaemia and acute intracranial hypertension are primary goals in managing the patient with head trauma. (60;81)

There is good evidence to allow the recommendation of suxamethonium as the sole paralytic agent (58;75;93). However, there is a paucity of evidence regarding which sedative provides adequate anaesthesia whilst attenuating a rise in ICP. Recommendation for thiopentone is based on a consensus of expert opinion and in light of most clinicians being familiar with its use.

5. In hypotensive trauma adults requiring emergency intubation in the ED, what is the optimal induction technique to minimise further haemodynamic instability?

GUIDELINE	Level Of Evidence
Thiopentone should be first-line choice of anaesthetic agent. Other options may include ketamine and etomidate but emphasis is given to the requirement for experience in their pharmacodynamic profiles before use. It is recommended that propofol should be avoided in this group of patients. Doses in Table 4.	Consensus
A fluid bolus should be administered at the time of induction to attenuate further haemodynamic compromise. Vasopressors are recommended second line to support the uncompensated hypotensive trauma patient. Recommended direct alpha agonists are phenylephrine or metaraminol in incremental boluses.	Consensus

5.1 Scientific Evidence

For the purpose of this review hypotension was defined as a systolic blood pressure (SBP) of less than 90 mmHg in adults and <100mmHg in adults over 55 years. In addition, evidence was sought to define the indications for, and selection of, vasopressors as an adjunct to emergency intubation of the hypotensive trauma patient. (Evidence Table 3) Studies identified are not directly applicable to RSI on hypovolaemic trauma patients in the ED.

The SHRED study (106) compared thiopental, fentanyl, and midazolam for RSI in the emergency department. The effect on mortality, ease and timing of intubation and affect on haemodynamic profile was measured. 86 patients were enrolled in the study, of which trauma patients constituted 14 (16.3%). All cases were intubated, 9 on the first attempt, 4 on the second and 1 on the third. There were no differences between the three groups in regards to mortality (24%, the number of intubation attempts ($p=0.45$) or visualisation score ($p=0.43$). A significantly higher rate of rapid intubation was achieved in the thiopental group than the midazolam or fentanyl group ($p=0.037$). Fentanyl produced the most neutral chronotropic profile (SBP -6.1 ± 61.4 , $p=0.045$). Midazolam was associated with an increase in BP and HR in response to intubation). SBP -7.1 ± 63.4 ; HR 17.2 ± 17.6 , $p<0.045$) Thiopental resulted in a moderate fall in BP (SBP $-38\text{mmHg} \pm 57.5$ $p=0.45$) shortly after administration and tended to cause a reflex tachycardia. Haemodynamic changes during intubation were most pronounced in patients presenting with pulmonary oedema, intracranial haemorrhage or whom required multiple attempts at intubation (106).

A study by Tammisto (107) examined the use of thiopentone for anaesthesia in patients after severe upper gastrointestinal haemorrhage. The study found that a severe fall BP if the patient was tachycardic or hypotensive. A fall in BP was 3 times more likely if patient unstable prior to induction.

Influence of haemorrhagic shock on the pharmacodynamics of various intravenous agents has been studied in swine. Reduction in dose requirements of thiopentone, ketamine and propofol by 30-40% have been demonstrated (108-111). Most comparable studies in humans have assessed cardiac patients with limited generalisability to traumatic hypovolaemia.

No studies were identified to indicate when vasopressors should be administered in hypovolaemic shock pending induction of anaesthesia.

There is consistency in identifying the requirement for reduced doses of intravenous agents but very limited evidence available to adequately answer this clinical question. Generalisability to trauma patients is doubtful hence the need for recommendations supported by expert opinion.

IV Fluids and Inotrope use

There were no studies identified that evaluated the prophylactic use of IV fluid loading or inotrope use to prevent hypotension post administration of induction drugs in trauma patients. There have been studies in patients undergoing elective surgery (112-116), but this was deemed not generalisable to the trauma patient. Recommendations are therefore based on consensus of expert opinion.

5.2 Discussion

In haemorrhagic shock a further fall in blood pressure at induction of anaesthesia may be catastrophic. Most pharmacological agents for sedation and paralysis induce a dose dependant hypotension with greater effect in hypovolaemic patients and the elderly (117). Slow administration counters these effects but then provides sub-optimal anaesthesia for RSI. While RSI is still the accepted basic technique to intubate this group of patients, modifications to the induction agents used may be necessary to attenuate further haemodynamic compromise (13;14).

Evidence to confirm the best location for intubation of this group of patients was not identified. On the understanding that many will require immediate surgery, whenever possible, induction of anaesthesia should be on the operating table to enable immediate surgical intervention. If this is not an option RSI must be performed in the Emergency Department by the most experienced operator available. Thorough knowledge of the profile of the agents to be used is imperative as the hypotensive patient has the potential for complete haemodynamic collapse at induction.

5.3 Conclusion

There is little evidence-base to answer this question. A consensus of opinion suggests that thiopentone should be first-line choice of anaesthetic agent. Other options may include ketamine and etomidate but emphasis is given to the requirement for experience in their pharmacodynamic profiles before use. It is recommended that propofol should be avoided in this group of patients. A fluid bolus should be administered at the time of induction to attenuate further haemodynamic compromise.

6. In the trauma adult requiring emergency control of the airway, what is the best treatment algorithm to follow for management of a “difficult airway”?

GUIDELINE	Level Of Evidence
Management of adults with Difficult Airways should be as per Algorithm 2 at the front of this guideline.	Consensus

6.1 Scientific Evidence

Algorithms for use in the emergency department have been previously formulated (121-123) but few are aimed specifically at the trauma scenario which presents specific challenge. (4). There is no evidence to state the optimal number of intubation attempts before alternative techniques are adopted and limited evidence to directly compare equipment for specific conditions. This evidence is unlikely to become rapidly available due to the highly variable conditions encountered with regards to patients, their injuries, the clinical situation and the operator managing the airway. Randomised clinical trials in this scenario have inherent difficulties in design and large numbers are required to enable comparison between groups.

A key feature in the algorithm is the use of oxygen saturation to assess adequacy of ventilation and hence represent end-organ tissue perfusion and oxygenation. This has room for error. Oxygen saturation monitoring by pulse oximetry using a light-emitting diode attached to a digit, ear or nose has recognised limitations (44). Particularly relevant to trauma, these include poor signal due to peripheral vasoconstriction related to hypovolaemia, cold or pre-existing peripheral vascular disease. Dependence on this measurement alone as a measure of ventilation must therefore be used with utmost caution.

Equipment options for inclusion in the algorithm are varied and will depend on operator experience and skill. The literature considers various techniques and equipment with the oral endotracheal tube declared optimal. Examples such as the Combitube, intubating laryngeal mask, lighted stylet and jet ventilation of the trachea may have a role in some institutions but are not recommended over the options described here.

The end-point of the algorithm to achieve a definitive airway is surgical cricothyroidotomy, an open technique requiring a surgical blade (size 11) and a size 6 endotracheal tube. Further details on technique are beyond the scope of this article but available in most good trauma texts. The literature suggests cricothyroidotomy rates of 2-3% in patients requiring emergency airway control in the ED (actually ranging between 0.3 and 12.4%) (9;11;124-129);(130). This is between 0.01 and 1.1% of the total number of ED admissions (11;124;126;129). Cricothyroidotomy is a procedure to be undertaken quickly and decisively without unnecessary extra attempts at intubation, this algorithm should prompt timely effective intervention in trauma patients with a difficult airway.

6.2 Discussion

In an emergency intubation by RSI, the difficult airway, by definition, is identified when the operator is unable to pass the endotracheal tube into the trachea. This differs from the accepted definition offered by the American Society of Anaesthesiology (121) which refers specifically to a conventionally trained anaesthetist having difficulty with face mask ventilation as well as intubation. RSI in the ED is undertaken by a range of specialists and initial face mask ventilation is avoided to reduce the risk of gastric dilatation and aspiration, instead after a period of pre-oxygenation, intubation is performed directly after induction of anaesthesia (Appendix C).

Difficult airway algorithms have been produced and implemented for use on patients undergoing procedures by trained anaesthetists in the controlled environment of the operating theatre (54;121-123;131). Trauma patients provide a distinct population who are likely to be the most challenging in terms of emergency airway control (132;133). In the subgroup of these patients who require immediate emergency intubation in the resuscitation room, there is little time to obtain extra equipment or second opinion.

Time to achieve a definitive airway, defined as a cuffed endotracheal tube, may be reduced by pre-existing hypoxia due to airway obstruction, chest injuries and severe hypovolaemia. An evidence-based algorithm to guide operators in this stressful scenario will accelerate management and optimise patient care.

As per all pre-operative assessments, anatomical variations contribute to the prediction of a 'difficult airway'. These include a small chin, obesity, large tongue, protruding dentition and a high arched palate. A full anaesthetic history and assessment is recommended whenever the situation allows (43;134;135). The standard pre-anaesthetic history may not be available but as a minimum a record of allergies is important whenever possible. Assessment of the Mallampati score (136) may be possible but is often limited by the urgency of the situation, a supine patient and limited mouth opening due to the cervical collar (44). Cervical spine precautions of a hard collar and/or manual in-line immobilisation must be considered at all times.

6.3 Conclusion

The algorithm produced by this working group provides simple, uncomplicated methodology for difficult airway management appropriate for all skill levels and ED environments. The clinical impact of the algorithm should therefore be significant with minimal resource implications.

Evidence Table 1 - Intubation and potential cervical spine injury

Author and Year	Level of Evidence	Quality	Study Question	Summary
Pennant 1993 (44)	II	A	A randomised trial comparing the difficulty, rapidity, and success rate of ventilating patients with immobilized cervical spines using a laryngeal mask airway and an endotracheal tube.(women scheduled to undergo elective gynaecologic surgery requiring general anaesthesia)	Hard collar reduces mouth opening by 60%. The laryngeal mask airway performed similarly to endotracheal tube in success rate, difficulty of insertion, and time to position correctly in this patient population. The laryngeal mask however does not reliably protect against aspiration and is therefore only recommended when more conventional methods of airway management fail. Further studies in the trauma scenario are indicated.
Brimacombe 2000 (20)	II	A	Comparison of: face mask ventilation (FM, laryngoscope-guided orotracheal intubation, fibroscope-guided nasal intubation oesophageal tracheal Combitube insertion, intubating laryngeal mask insertion with fibroscope-guided tracheal intubation, and laryngeal mask airway insertion (LMA).	Significant displacement of the injured segment (C3) occurred during airway management with the face mask, laryngoscope-guided oral intubation, the oesophageal tracheal, the intubating and standard laryngeal mask airway; but not with fibroscope-guided nasal intubation. The safest airway technique with this injury is fibroscope-guided nasotracheal intubation. Laryngeal mask devices are preferable to the oesophageal tracheal Combitube.
Nolan 1993 (19)	II	A	The view of the larynx obtained during laryngoscopy with the head in the optimum intubating position was compared with that obtained when manual in-line stabilisation of the cervical spine and cricoid pressure were used. Patients were randomised to either direct visual intubation (n = 79, or intubation aided by a gum elastic bougie (n = 78)	During laryngoscopy with cervical stabilisation, the view of the larynx was reduced in 45% of patients, and in 22% of patients nothing was visible beyond the epiglottis. The median time taken for visual intubation was 20 s.(max 45 secs).5 patients failed intubation. Using the gum elastic bougie all patients, including the failures from the visual group, were intubated within 45 s (median 25 s). Authors recommend use of a gum elastic bougie in patients with suspected cervical spine injury particularly when the glottis is not immediately visible.

Author and Year	Level of Evidence	Quality	Study Question	Summary
Gerling 2000 (21)	II	A	A randomised trial comparing the effects of manual in-line stabilisation and cervical collar immobilization and 3 different laryngoscope blades (Miller straight blade, the Macintosh curved blade, and the Corazelli-London-McCoy hinged blade) on cervical spine movement during OTI in a cadaver model of cervical spine injury	MILS results in less cervical subluxation and allows better vocal cord visualization during OTI in a cadaver model of cervical spine injury the hard collar. The Miller laryngoscope blade allowed less axial distraction than the Macintosh or Corzelli-London-McCoy blades. The clinical significance of this degree of movement is unclear.
Shulman 2001 (48)	II	A	To compare the Bullard laryngoscope (BL) with the flexible fiberoptic bronchoscope (FFB) in a cervical spine injury model, using inline stabilisation.	The times for laryngoscopy and intubation were longer in the flexible fiberoptic bronchoscope (FFB) group than in the BL group ($p < 0.004$). There was a significantly lower success rate of laryngoscopy view in the FFB group in the presence of cricoid pressure (15 of 25 patients, or 60%) than either of the Bullard laryngoscope groups or the FFB no-cricoid pressure group. The BL is more reliable, quicker, and more resistant to the effects of cricoid pressure than is the FFB
Watts 1997 (27)	II	A	To compare cervical spine extension (measured radiographically) and time to intubation with the Bullard and Macintosh laryngoscopes during a simulated emergency with cervical spine precautions taken	Manual ILS with the Bullard laryngoscope resulted in less cervical spine extension (5.6 ± 1.5 degrees) when compared to Macintosh blade (12.9 ± 2.1 degrees). The Bullard laryngoscope prolonged time to intubation (20.3 ± 12.8 s vs 40.3 ± 19.5 s; $P < 0.05$). This suggests that the Bullard laryngoscope may be a useful adjunct to intubation of patients with potential cervical spine injury when time to intubation is not critical.
Smith 1999 (31)	II	A	Randomised clinical trial Cant find smith in Medline/Embase	Tracheal intubation using the fiberoptic laryngoscope was associated with lower intubation difficulty and better views of the laryngeal aperture in patients with cervical immobilization when compared with conventional laryngoscopy. However, there were no differences in success rates or number of intubation attempts.

Author and Year	Level of Evidence	Quality	Study Question	Summary
Brimacombe 1993 (49)	II	A	To assess the ease of insertion of the laryngeal mask airway with the patient's head in the standard position and the neutral position was compared in a study of 80 healthy patients.	95% success rate when MILS compared 100% without stabilising C-spine LMA can be used in this group of patients with reasonable success rate.
Keller 1999 (26)	II	A	To measure the pressures exerted by the standard laryngeal mask airway (LMA) and the intubating laryngeal mask airway (ILM) against the cervical vertebrae during insertion, intubation, and compare these to pressures measured during laryngoscopy- and fiberoptic-guided oro/nasotracheal intubation. The effect of these pressures on cervical spine movement were also assessed.	Maximum pressure for the LMA and ILM was similar during insertion (224 vs 273 cm H2O) but higher for the ILM during fiberoptic-guided intubation (96 vs 43 cm H2O; P < 0.0001) During laryngoscopy, pressure was increased during handle depression (394 cm H2O; P < 0.0001) and partial withdrawal/reinsertion (265 cm H2O; P < 0.0001) but decreased during handle elevation (6 cm H2O; P < 0.00001). The mean (range) for posterior displacement of C3 was 0.8 (0-2) mm at 100 cm H2O and 2.8 (1-5) mm at 400 cm H2O. Laryngeal mask devices exert greater pressures against the cervical vertebrae than established intubation techniques and can produce posterior displacement of the C-spine. Laryngeal mask devices should therefore only be used in the unstable cervical spine if difficulties are anticipated or encountered with established techniques.
Waltl 2001 (50)	II	A	To assess movement of the upper cervical spine during tracheal intubation using direct laryngoscopy in healthy young patients	The intubating laryngeal mask (Fastrach) caused less extension (at C1-2 and C2-3) than intubation by direct laryngoscopy. Direct laryngoscopy was the fastest way of securing an airway provided no intubating difficulties are present. However, in trauma patients requiring rapid sequence induction and in whom cervical spine movement is limited or undesirable, the intubating laryngeal mask (Fastrach) provides a safe and fast method.

Author and Year	Level of Evidence	Quality	Study Question	Summary
Asai 2000 (51)	II	A	To compare the ease of tracheal intubation either using a Macintosh laryngoscope and gum elastic bougie with the ease of tracheal intubation through the intubating laryngeal mask using a fiberoptic bronchoscope during manual in-line stabilisation of the patient's head and neck.	The success rate and ease of tracheal intubation in laryngeal mask group (17 patients) was significantly higher than in elastic gum bougie group (nine patients) ($p < 0.01$). Time taken to intubate was also shorter in the laryngeal mask group (95% CI for difference: 8-50 s)
Inoue 2002 (52)	II	B2	To compare Trachlight to Fastrach for tracheal intubation in patients who had clinical and/or radiographic evidence of cervical abnormality.	Lightwand success 97.3% and faster, Fastrach had a 73% success rate. Lightwand was faster than trachlight (23 ± 9 s versus 71 ± 24 s). The Trachlight may be more advantageous for orotracheal intubation in patients with cervical spine disorders than the Fastrach with respect to reliability, rapidity and safety.
Carley 2001 (53)	III-2	B2	Systematic review of the literature evaluating the usefulness of the gum elastic bougies in difficult intubation	One paper was retrieved (Nolan, 1993; see above) Mean time to intubation is longer when using the bougie (20 secs vs 25 secs) although this time may not be clinically important. Gum elastic bougie facilitates intubation.
Jones 2002 (54)	III-2	B2	Short cut review	Gum elastic bougie facilitates intubation
Carley 2000 (55)	III-2	B2	Short cut review	McCoy better than Macintosh to view cords when Csp immobile
MacIntyre 1999 (29)	III-1	A	To evaluate cervical spine movement in patients scheduled for general surgery during intubation using the MacIntosh or McCoy blade with a cervical collar insitu (laryngoscopy grade 1 in all patients)	Intubation causes movement at C1-2 more than rest of C-spine. The range of extension at this joint was 3-25°. There was no significant difference in cervical spine movement between the McCoy laryngoscope or the standard Macintosh blade.

Author and Year	Level of Evidence	Quality	Study Question	Summary
Majernick 1986 (23)	III-2	A	<p>To measured cervical spine movement during orotracheal intubation in 16 anesthetized patients without neck injury, using straight and curved laryngoscope blades without stabilisation, Philadelphia collar stabilisation, and in-line stabilisation</p> <p>Cannot find this reference in medline</p>	<p>There was a significant decrease in movement when in-line stabilisation was applied ($P = 0.0056$). Although none of the methods tested totally prevented cervical spine movement during orotracheal intubation, the least movement was obtained by the use of in-line stabilisation by an assistant. The type of laryngoscope blade used or application of a Philadelphia collar did not reduce movement significantly</p>
Donaldson 1997 (25)	III-2	A	<p>To measure motion of the unstable spine at C1-C2 during intubation manoeuvres.</p>	<p>Oral intubation was equivalent to nasal intubation in terms of cervical spine movement.</p> <p>Chin lift and jaw thrust caused more movement</p> <p>Caution, jaw thrust.</p> <p>No advantage to nasal intubation shown</p>
Lennarson 2001 (24)	III-2	A	<p>To characterize and compare segmental cervical motion during orotracheal intubation in cadavers with and without a complete subaxial injury, as well as to examine the efficacy of commonly used stabilisation techniques in limiting that motion.</p>	<p>MILS best method to minimise c-spine movement for ETT placement</p>
Heath 1994 (22)	III-2	B1	<p>To compare cervical spine immobilisation in a rigid collar with tape across the forehead and sandbags on either side of the neck, to manual in-line immobilisation on view on laryngoscopy</p>	<p>66% had better scope views with MILS rather than sandbags/tape. ($p < 0.0001$).</p> <p>There was a poor view on laryngoscopy (grade 3 or 4) in 64% of patients when immobilised in a collar, tape and sandbags compared to 22% of patients undergoing in-line manual immobilisation ($p < 0.001$). Mouth opening was significantly reduced when patients were wearing cervical collars and this was the main factor contributing to the increased difficulty of laryngoscopy in this particular form of cervical spine immobilisation. It is recommended that manual in-line immobilisation should be the method of choice for cervical spine stabilisation during tracheal intubation.</p>

Author and Year	Level of Evidence	Quality	Study Question	Summary
Donaldson 1993 (56)	III-2	B2	To directly measure cervical spine during movement during airway manoeuvres before and after a C5-6 posterior instability	All techniques move c-spine included simple airway manoeuvres. Chin lift/jaw thrust and cricoid pressure can cause as much motion as do some of the intubation techniques
Konishi 1997 (28)	II	(no quality-abstract only)	To compare movement of the cervical spine during laryngoscopy using either the McCoy, Macintosh or Miller laryngoscope blade	The use of the McCoy laryngoscope results in less cervical spine movement during laryngoscopy and therefore should be of particular benefit in the presence of cervical spine instability as well as in the normal patients.
Criswell 1994 (33)	IV	B2	A retrospective review of patients presenting to a trauma centre with spinal injuries requiring intubation	73 patients were intubated orally following a rapid sequence induction with the application of cricoid pressure and manual in-line stabilisation of the head and neck. There were no neurological sequelae in these 73 patients (95% confidence interval 0-4%). RSI / MILS / cricoid safe effective way to intubate
Sakles, J. 1998 (11)	IV	A	A prospective review of tracheal intubations undertaken in the emergency department. (47.7% patients were trauma related)	RSI was the technique of choice 89.9% of patients, 99.2% being completed successfully. The success rate in patients which did not receive neuromuscular blocking agents was 91.5%. There was an 8% complication rate. The most common immediate complication (3.2%) was desaturation (<85%). But was not associated with any disability at discharge, The second most common complication (3%) was right main stem intubation, none resulting in pneumothorax or hypoxaemia.

Evidence Table 2 - Induction agents in patients with severe head injury

Author and Year	Level of Evidence	Quality	Study Question	Summary
(i) Neuromuscular Blockade				
Perry 2003 (75)	I	A	To determine if rocuronium creates comparable intubating conditions to succinylcholine during RSI.	Succinylcholine created superior intubation conditions to rocuronium when comparing excellent intubation conditions. Overall, rocuronium was inferior to succinylcholine, with a RR=0.87 (95%CI = 0.81 to 0.94) (N=1606).
Andrews 1999 (94)	II	A	To compare rocuronium versus succinylcholine in rapid-sequence induction of anaesthesia	Rocuronium 1.0 mg/kg given along with propofol in a rapid-sequence induction of anaesthesia is clinically equivalent to succinylcholine 1.0 mg/kg.
Brown 1996 (93)	II	A	To establish the affect of suxamethonium on intra-cranial pressure and mean arterial pressure in intubated head injured patients	There were no significant changes in intracranial pressure or cerebral perfusion pressure (CPP) following the administration of suxamethonium or saline. Suxamethonium appears to be a safe drug to use on sedated persons with severe head injuries.
Magorian 1993 (58)	III-1	A	To compare rocuronium with succinylcholine and vecuronium for rapid-sequence induction of anaesthesia. Doses rocuronium (0.6, 0.9, and 1.2 mg/kg, vecuronium (0.1 mg/kg, or succinylcholine (1.0 mg/kg)	Longer onset times were experienced in patients receiving smaller doses of rocuronium (89 +/- 33 s) and vecuronium (144 +/- 39 s) Clinical duration of action was longest with 1.2 mg/kg rocuronium, similar with 0.6 and 0.9 mg/kg rocuronium, and vecuronium, and least with succinylcholine.
Sparr 1996 (95)	III-1	A	Quasi Randomised Trial Cannot find this study in Medline	Rocuronium compares with suxamethonium for intubation conditions

Author and Year	Level of Evidence	Quality	Study Question	Summary
Koenig 1992 (57)	III-1	B1	To evaluate the effectiveness of a midose succinylcholine in combination with a defasciculating dose of pancuronium to prevent the ICP rise and emesis with aspiration that can occur secondary to fasciculations.	All patients received lidocaine (1 mg/kg) IV . 8/19 (42%) in the pancuronium group and 6/27 (22%) in the succinylcholine group experienced fasciculations. No statistically significant difference in fasciculations was detected between the two groups Pre-treatment with midose succinylcholine causes no greater incidence of fasciculations than pancuronium in rapid-sequence intubation of head trauma patients in an ED setting.
Stirt 1987 (96)	III-1	B1	To test whether a small, "defasciculating" dose of metocurine could prevent increases in intracranial pressure (ICP) induced by succinylcholine.	ICP rise if suxamethonium may induce marked ICP increases in lightly anesthetized patients with intracranial mass lesions. Pre-treatment with a "defasciculating" dose of metocurine can prevent these potentially deleterious ICP increases in patients known to be at risk.
Minton 1986 (97)	III-2	C	To test the effect of succinylcholine on ICP in patients with brain tumors who received succinylcholine both before and after complete neuromuscular blockade with vecuronium.	Mean ICP increased from 15.2 mmHg +/- 1.3 after suxamethonium vs no patient developed an increase in ICP greater than 3 mmHg ICP if vecuronium was given before suxamethonium. (p<0.05)
Bekker 1999 (90)	Scientific Modelling IV	B1	To review the use of a computer simulation program to examine the effects of various stimuli occurring during anesthesia on cerebral blood flow (CBF) and intracranial pressure (ICP).	Simulation shows that the induction dose of intravenous anaesthetic reduces ICP up to 30% (propofol > thiopental > etomidate). The duration of this effect is limited to less than 5 minutes by rapid drug redistribution and cerebral autoregulation. Subsequent laryngoscopy causes acute intracranial hypertension, exceeding the initial ICP.
Takehita 1972 (98)	IV	B2	To measure the effects of ketamine on cerebral circulation and metabolism in healthy subjects.	ICP increases with ketamine anaesthetic in healthy pt

Author and Year	Level of Evidence	Quality	Study Question	Summary
Kovarik 1994 (99)	IV	C	The measure the effect of succinylcholine on intracranial pressure (ICP) in 10 mechanically ventilated patients	In brain-injured patients, succinylcholine did not alter cerebral blood flow velocity, cortical electrical activity, or ICP
(ii) Sedation				
De Nadal 2000 (72)	II	B1	To investigate the effects of morphine and fentanyl upon intracranial pressure and cerebral blood flow	Both morphine and fentanyl caused significant increases in intracranial pressure ($P = 0.008$ with morphine and $P = 0.044$ with fentanyl) and decreases in mean arterial blood pressure ($P = 0.002$ and 0.016 , respectively) and cerebral perfusion pressure ($P = 0.001$ and $P < 0.0001$, but estimated cerebral blood flow remain unchanged. In patients with preserved autoregulation, opioid-induced intracranial pressure increases were not different than in those with impaired autoregulation.
Sperry 1992 (73)	II	B1	To examine the effects of opioids (fentanyl (3 micrograms.kg-1) or sufentanil (0.6 microgram.kg-1)) on intracranial pressure on patients with severe head trauma.	Fentanyl was associated with an average ICP increase of 8 ± 2 mmHg, and sufentanil with an increase of 6 ± 1 mmHg. ($P < 0.05$ for both) Both drugs produced clinically mild decreases in mean arterial blood pressure (fentanyl, 11 ± 6 mmHg; sufentanil, 10 ± 5 mmHg) ($P < 0.05$ for both)
Albanese 1999 (68)	III-1	B2	To determine the effects of bolus injection and infusion of sufentanil, alfentanil, and fentanyl on cerebral hemodynamics and electroencephalogram activity in patients with increased intracranial pressure (ICP) after severe head trauma	Sufentanil, fentanyl, and alfentanil infusions were associated with a significant but transient increase in ICP (9 ± 2 mm Hg [SD], 8 ± 2 mm Hg, and 5.5 ± 1 mm Hg, respectively; $p < .05$). A significant decrease in MAP (21 ± 2 mm Hg, 24 ± 2 mm Hg, and 26 ± 2 mm Hg, respectively; $p < .05$) and, thus, in CPP (30 ± 3 mm Hg, 31 ± 3 mm Hg, and 34 ± 3 mm Hg, respectively; $p < .05$).
Hanowell 1993 (100)	III-1	B2	To measure effects of i.v. alfentanil on the intracranial pressure (ICP) and cerebral perfusion pressure (CPP) during endotracheal suctioning of head-injured adults.	Alfentanil significantly reduces CPP on suction.

Author and Year	Level of Evidence	Quality	Study Question	Summary
White 1982 (74)	III-1	B2	To study the affects of fentanyl, lignocaine, succinylcholine, lignocaine intratracheally, or placebo in attenuating ICP rise associated with endotracheal suctioning	Suxamethonium resulted in no increase in ICP post suctioning (0; p<0.05). Fentanyl (1,mcg/kg) saw a mild elevation (+1), Thiopentone (+7, IV lignocaine (+4, intratracheal lignocaine (+4) and normal saline (+9).
Weinstabl 1992 (70)	III-2	B2	To test the effect of Fentanyl and sufentanil on intracranial pressure in head trauma patients	At doses over 1mcg/kg, Cerebral Blood Flow Velocity and Cerebral Perfusion Pressure fall There was no change in ICP from wither drugs. Mean arterial pressure however, fell.
Werner 1995 (71)	III-2	B2	To measure the effects of sufentanil (3 mcg/kg) on cerebral blood flow velocity and intracranial pressure (ICP) in 30 patients with intracranial hypertension after severe brain trauma	ICP increases after sufentanil if MAP falls>10mmHg 12/30 (40%) patients experienced a drop in mean arterial pressure if >10mmHg, These patients also experienced an increase in mean arterial pressure.
Bekker 1999 (90)	Scientific Modelling IV	B1	To review the use of a computer simulation program to examine the effects of various stimuli occurring during anaesthesia on cerebral blood flow (CBF) and intracranial pressure (ICP).	Simulation shows that the induction dose of intravenous anaesthetic reduces ICP up to 30% (propofol > thiopental > etomidate). The duration of this effect is limited to less than 5 minutes by rapid drug redistribution and cerebral autoregulation. Subsequent laryngoscopy causes acute intracranial hypertension, exceeding the initial ICP.
Unni 1984 (65)	IV	B2	Review of anaesthesia induced by: thiopentone 5 mg kg-1 given over 1 min, followed by pancuronium 0.1 mg kg-1. After manual hyperventilation with nitrous oxide and oxygen for 3 min, thiopentone 2.5 mg kg-1 over 30 s was administered (phase 1); 30 s later laryngoscopy was performed and topical analgesia administered to the larynx. Endotracheal intubation was performed 1 min after spraying the cords (phase 2).	There was a significant decrease (P < 0.05) in MAP at the end of the second dose of thiopentone, there were no other significant changes in ICP, MAP or Pa(CO2) throughout the study. In two patients there were transient decreases in cerebral perfusion pressure to less than 60 mm Hg.

Author and Year	Level of Evidence	Quality	Study Question	Summary
(iii) Adjuncts				
Robinson 2001 (59)	I	B1	A systematic review to determine if pre-treatment with lignocaine improves neurological outcome in patient with head injury undergoing RSI	No study was identified that evaluated the use of lignocaine prior to RSI. The authors conclude until this practice has been scientifically evaluated, it use should not be recommended.
Levitt 2001 (62)	II	A	To assess the effect of esmolol vs lidocaine to attenuate the detrimental rise in heart rate and blood pressure during intubation of patients with isolated head trauma.	Lignocaine and Esmolol similarly attenuate haemodynamic response to RSI [(mean difference in heart rate 4.0 beats/min (95% CI = -17.7 to 9.7 beats/min) mean difference in systolic blood pressure 1.3 mm Hg (95% CI = -27.8 to 30.4 mm Hg, and for diastolic blood pressure was 2.6 mm Hg (95% CI = -27.1 to 21.9 mm Hg)
Clancy 2001 (101)	III-2	B1	To determine if pre-treatment with lignocaine attenuates a rise in intracranial pressure in head injured patients undergoing RSI.	There was no studies identified in this review that evaluated the use of lignocaine prior to RSI.
Donegan 1980 (64)	III-1	B1	To evaluate the effectiveness of IV lignocaine in preventing a rise in intracranial pressure prior to endotracheal suctioning	Lignocaine attenuated an ICP rise post endotracheal suctioning. Subgroup on hourly pentobarbital responded even better.
Feng 1996 (66)	III-1	B1	To evaluate the efficacy of esmolol compared to fentanyl and lignocaine in attenuating the hyperdynamic consequences of intubation during induction of general anesthesia,	Esmolol reliably attenuated the increase in both HR and SBP, low dose of fentanyl (3 micrograms/kg) prevented hypertension but not tachycardia, and 2 mg/kg lidocaine had no effect to blunt adverse hemodynamic responses during laryngoscopy and tracheal intubation. (P<0.05)
Hamill 1980 (67)	III-1	B2	To evaluate intratracheal and IV lignocaine to attenuate the haemodynamic response to intubation	Lignocaine attenuates ICP rise on intubation
White 1982 (74)	III-1	B2	To study the affects of fentanyl, lignocaine, succinylcholine, lignocaine intratracheally, or placebo in attenuating ICP rise associated with endotracheal suctioning	Suxamethonium resulted in no increase in ICP post suctioning (0; p<0.05). Fentanyl (1,cg/kg) saw a mild elevation (+1), Thipentone (+7, IV lignocaine (+4, intratracheal lignocaine (+4) and normal saline (+9).

Author and Year	Level of Evidence	Quality	Study Question	Summary
Kerr 1998 (102)	III-2	B1	To examine the effect of morphine sulphate and fentanyl citrate or vecuronium on cerebrovascular response to endotracheal suctioning in adults with severe head injuries.	Changes in intracranial pressure were significantly smaller in subjects who received a neuromuscular blocking agent plus opiates than in subjects who did not receive any drugs or received opiates only.
Yano 1986 (103)	III-2	C	To measure the affect of lignocaine in preventing ICP rise during and after endotracheal suctioning	No elevation of ICP measured post suctioning -suggested as a result of the intervention. Tracheal more effective.
Bedford 1980 (104)	III-2	B2	To measure the effectiveness of intravenously administered lignocaine (1.5 mg/kg IV) for rapid control of acute intracranial hypertension was compared to the effectiveness of thiopental (3 mg/kg IV) in 20 patients with brain tumors undergoing craniotomy	Lidocaine reduced ICP 15.7 torr +/- 5.6 SE (p < 0.025) but did not significantly affect mean arterial pressure. In contrast, thiopental lowered ICP 18.4 torr +/- 9.6 SE (p < 0.02) and also lowered mean arterial pressure by 26.1 torr +/- 9.6 SE (p < 0.025).
Moss 1979 (105)	IV	C	To measure the effect of etomidate (0.2 mg kg-1 i.v) on intracranial pressure in en patients with intracranial lesions, anaesthetized with thiopentone and nitrous oxide (70%) in oxygen (30%).	Mean Arterial Pressure decreased in most patients, but the decrease was statistically significant only at 3 and 4 min after the administration of etomidate (0.05 > P > 0.02). The changes in cerebral perfusion pressure and heart rate were not clinically or statistically significant. It is concluded that etomidate can be used for the induction of anaesthesia in patients with intracranial space-occupying lesions without increasing ICP or seriously reducing CPP.

Evidence Table 3 - Induction agents and hypotensive trauma patients

Author and Year	Level of Evidence	Quality	Study Question	Summary
Chiu 2001 (112)	II	A	To evaluate the efficacy of prophylactic metaraminol for preventing propofol-induced hypotension 30 patients aged 55-75 years undergoing general anaesthesia	Induction of anaesthesia was associated with a decrease in mean and systolic arterial pressure in both groups ($p = 0.0001$) with no difference in BP drop between groups. Prophylactic use of metaraminol 0.5 mg does not prevent the decrease in blood pressure following fentanyl and propofol induction in older patients.
El-Beheiry 1995 (113)	II	A	To determine the effectiveness of ephedrine sulphate (70 micrograms x kg(-1)iv) or pre-induction volume loading (12 ml x kg(-1) Ringer's lactate) to protect against the anticipated hypotension induced by propofol (2.5 mg. x kg(-1)) during rapid-sequence intubation in 36 patients (ASA Grade I or II) under going elective outpatient surgery	Pre-induction volume loading prevented the hypotension observed before surgical stimulation in control and ephedrine groups. Pre-induction volume loading was not associated with increases in heart rate after intubation as was ephedrine administration
Gamlin 1996 (114)	II	A	To compare the haemodynamic effects of adding different doses of ephedrine to an induction dose of propofol in 40 ASA1 patients presenting for minor gynaecological surgery.	In those patients who received propofol alone, there was a significant decrease in both systolic ($p < 0.001$) and diastolic ($p = 0.003$) blood pressure. The addition of ephedrine 15 mg or 20 mg to 1% propofol 20 ml was very effective in maintaining blood pressure at pre-induction values. There was a statistically significant increase from baseline in systolic ($p = 0.004$) and diastolic ($p = 0.031$) pressures, but this only occurred at 1 min postinduction.
McCullum 1986 (118)	III-2	B1	To compare the effects of the induction characteristics of thiopentone, etomidate and methohexitone to those of propofol in unpremedicated patients.	Propofol 2.5 mg/kg, etomidate 0.3 mg/kg and methohexitone 1.5 mg/kg caused significantly excitatory side effects and pain on injection at the dorsum of hand than thiopentone 5 mg/kg. Propofol 2.5 mg/kg caused significantly more hypotension. Propofol 2.0 mg/kg was equipotent with thiopentone 4.0 mg/kg in terms of successful induction of anaesthesia. Hypotension may contraindicate the use of propofol in the hypovolaemic or unfit patient

Author and Year	Level of Evidence	Quality	Study Question	Summary
Michelsen 1998 (115)	II	A	To compare the effect of prophylactic administration of ephedrine (0.1 mg/kg, or ephedrine 0.2 mg/kg i.v) against the hypotensive effect of propofol in elderly female patients scheduled for minor gynaecological procedures	The decrease in blood pressure and heart rate (HR) was significantly less in each of the ephedrine groups (P < 0.001). The decrease was less in the large-dose group compared with the small-dose group (P < 0.05). The prophylactic injection of ephedrine decreased but did not abolish the decrease in blood pressure associated with induction of anesthesia with fentanyl and propofol.
Sivilotti 1998 (106)	II	A	To compare thiopental (5mg/kg, fentanyl (5mg/kg, and midazolam (100mcg/kg) for rapid-sequence induction and intubation (RSI) in 86 patients undergoing RSI in the emergency department	Thiopentone resulted in a mean systolic blood pressure reduction of 38 mm Hg (P=.045, but provided the best intubating conditions. Midazolam group had a greater number of delayed intubations (31%) and an average heart rate increase of 17 beats/minute (P=.008). Fentanyl provided the most neutral hemodynamic profile during RSI but had a similar number of delayed intubations as midazolam.
Turner 1998 (116)	III-1	B1	To evaluate the effectiveness of 20 ml kg-1 of crystalloid fluid preload over 20 min or to receive no fluids before induction of propofol/fentanyl anaesthesia to prevent hypotension in 58 women (ASA I or II) undergoing elective gynaecological procedures,	A significant decrease in systolic arterial pressure (< 75% of baseline value) occurred in both the fluid-loaded and the control groups,
White 1982 (74)	II	B1	To compare the effects of Thiopental (4 mg/kg, ketamine (1.5 mg/kg or 0.75mg/kg, midazolam (0.3 mg/kg or 0.15 mg/kg) for rapid induction of general anesthesia in 80 patients undergoing emergency surgery	During induction, thiopental decreased mean arterial pressure (MAP) by 11%, ketamine increased MAP by 10%, while neither midazolam nor the midazolam-ketamine combination significantly changed MAP. Midazolam had the slowest onset (15-60 s) and longest duration of action.

Author and Year	Level of Evidence	Quality	Study Question	Summary
LA Sivilotti 1998 (106)	II	B1	To compare the effects of Thiopental, Fentanyl, or midazolam on the haemodynamics and ease of intubation during RSI in patients needing intubation in the Emergency Department. (not trauma, not head injured patients)	Of the patients who received thiopental, 93% were intubated within 2 minutes of paralysis (P=.037, but systolic blood pressure fell an average of 38 mm Hg in this group (P=.045). The midazolam group had a greater number of delayed intubations (31%) and an average heart rate increase of 17 beats/minute (P=.008). In all three groups, patients with pulmonary oedema had the greatest decrease in blood pressure during RSI, and patients exposed to multiple attempts at intubation manifested pronounced hypertension.
Davis 2001 (119)	IV	B1	To examine the does response between midazolam and hypotension during RSI in the prehospital setting	Midazolam for RSI was associated with dose-dependent hypotension. Low dose midazolam(<5mg) assoc with less hypotension (6% vs 21%)
Smith 2000 (120)	IV	B1	To determine the safety and utility of etomidate in patients requiring intubation in the emergency department	Etomidate was safe and effective for RSI with minimal effects on BP. 3% fall BP in trauma subgroup
Hug 1993 (117)	III-2		To investigate clinically important hypotension and bradycardia after induction of anesthesia with propofol	The overall incidence of hypotension (systolic blood pressure <90 mm Hg) was 15.7%; 77% of the episodes were recorded within 10 min of induction of anesthesia with propofol. Bradycardia (heart rate <50 beats/min) occurred in 4.8% of patients, with 42% of the episodes in the first 10 min Hemodynamic changes were transient and rarely (<0.2%) required drug therapy.
Tammisto 1973 (107)	IV	B1	Retrospective Case Series To compare althesin and thiopentone in induction of anaesthesia	SBP<100 needed 2-4mg/kg Thiopentone compared to >4 if HR> 100 or normal haemodynamics. Severe fall BP if patient was tachycardic or hypotensive. A fall in BP was 3 times more likely if patient unstable prior to induction.

Evidence Table 4- Managing difficult airways

Author and Year	Level of Evidence	Quality	Study Question	Summary
Salvino CK 1993 (129)	IV		A retrospective review of 30 cricothyroidotomies performed in patients admitted to a level 1 trauma centre (may occur prior to admission)	No major complications experienced among the 30 cricothyroidotomies performed. 13.3% minor complication rate (infection, minor bleeding, minimal subglottic stenosis)
Chang RS 1998 (128)	IV	C	A retrospective review to report the change in cricothyroidotomy rate in adult trauma patients	During the years 1985-89, the cricothyroidotomy rate was 1.8% (95% CI: 1.6 to 2.0) compared to 0.2% (95% CI: 0.0 to 0.2) during the period 1993-4. ATLS starting to be taken up with ETT and MILS recommended. RSI with paralysis not yet used routinely in this centre.
Fan 2000 (137)	II	A	To determine if the Trachlight lightwand can facilitate Fastrach intubation by guiding the tip of the endotracheal tube into the trachea in 172 elective surgical patients.	There were no differences in the times to place the Fastrach, and endotracheal tube. However, blind intubation with the iLMA had a 76% success rate compared to 95% success rate when the lightwand was used as an adjunct.
Vollmer 1985 (138)	IV		To assess the usefulness of a light-guided stylet on the ease of intubation	24 attempts at intubation in 21 pts using blind intubation , 88% success rate using the lighted stylet by Drs in pre-hospital scenarios
Baskett 1998 (139)	III-3	A	A multicentre trial of the use of the intubating laryngeal mask in 500 ASA grade 1 and 2 patients.	The laryngeal mask was successfully inserted in all 500 patients. Ventilation via the intubating laryngeal mask was described as satisfactory in 475 (95%) cases, difficult in 20 (4%) cases and unsatisfactory in 5 (1%) cases. Blind tracheal intubation was possible in 96.2% within three attempts.

Author and Year	Level of Evidence	Quality	Study Question	Summary
Mlinek 1990 (140)	IV	B2	A retrospective review of emergency airway management in the emergency department who underwent fiberoptic-aided endotracheal intubation; 4/31 were trauma patients.	All four trauma patients were intubated successfully, and all attempts were done nasally. The mean time of the four trauma cases was 3 +/- 2.2 minutes Success rate (83%) and time (2-3+++ mins) longer in the trauma pts. Trauma was only 11% total. Fibreoptic is an option as an adjunct but has disadvantages in ED, especially financial. Repair or replacement of broken equipment appears to be necessary every two or three years. The authors conclude immediate airway control is often difficult with fiberoptic-aided endotracheal intubation and should be used only in selected patients.
Blostein 1998 (141)	IV	A	Case series	10 pts failed RSI pre-hosp flight nurses used combitube. 100% success rate at insertion. Note 80% success rate of RSI. Combitube easy and good for failed RSI.
Hawkins 1995 (127)	IV	B1	To review the rate and safety of Cricothyrotomy at a level 1 trauma cent	Cricothyrotomy was required in 66/525 (12.4%) patients who required emergency airway control but could not be intubated nonsurgically in an expeditious manner. There were 3 major complications (thyroid cartilage laceration, significant haemorrhage, and failure to obtain a surgical airway, but each resolved without sequelae. Cricothyrotomy feasible and safe with risk of minor complications
Young 2003 (142)	IV	B2	To evaluate the intubating laryngeal-mask airway (ILMA) as a device for airway control in the rural trauma patient.	Near 100% success at placement and 90% for the beginners after one attempt and minimal training. Easier technique than ETC and ETT ILMA good for diff airways and when inexperienced with laryngoscopy

Author and Year	Level of Evidence	Quality	Study Question	Summary
DeLaurier 1990 (143)	IV	B2	A retrospective review of emergency cricothyroidotomies performed in trauma patients in the emergency department	Increased complications if followed by tracheostomy but rate attributable directly to the cricothyroidotomies of about 30%. Authors conclude the use of emergency cricothyroidotomy in situations in which intubation is not successful or thought to be safe is acceptable.
Graham 2003 (9)	III-2	B1	To determine current practice for rapid sequence intubation (RSI) in a sample of emergency departments in Scotland	Anaesthetics got better views and more first pass but on less sick patients (91.8% versus 83.8%, p=0.001) Emergency physicians intubated a higher proportion of patients with physiological compromise (91.8% versus 86.1%, p=0.027) and a higher proportion of patients within 15 minutes of arrival (32.6% versus 11.3%, p<0.0001). There was a non-significant trend to more complications in the group of patients intubated by emergency physicians (8.7% versus 12.7%, p=0.104)
Dufour 1995 (10)	IV	B1	To review 219 RSI in the emergency department and assess the related morbidity and mortality	100% success at intubation 10% hypotension (using midazolam 0.1mg/kg) 15% complications overall including these 100% success rate intubating with paralysis by emergency physicians
Vijayakumar 1998 (126)	IV	B1	To examine the relationship between the occurrence of a difficult intubation and (1) the use of neuromuscular blocking agents (NMB) and (2) the presence of airway injuries in trauma patients .	The use of succinylcholine was associated with a lower risk of difficult intubations compared with intubations where a nondepolarizing NMB was used. 97% success rate , with 3% of patients needing cricothyroidotomy. 15% difficult intubation – but this was not associated with potential airway / c-spine injuries

Author and Year	Level of Evidence	Quality	Study Question	Summary
Hunt 1989 (144)	IV	B2	To prospectively evaluate the effectiveness of training evaluate for EMT providers using the pharyngeal tracheal lumen (PTL)	32 paramedics / EMT's trained with pharyngeal tracheal airway then tested at 6 weeks for competence. Combitube not necessary, straight forward to use
ASA 2003 (121)	III-2	A	Practice guidelines for management of the difficult airway	Practice guidelines for management of the difficult airway. Levels of evidence assessed and recommendations produced
EAST 2002 (4)	III-2	B	Practice guidelines for emergency airway management in trauma patients	Systematic review to identify who should be intubated and what the equipment / adjuncts are. Limited search to medline and english language
Crosby 1998 (131)	III-2	A	To review the current literature and generate recommendations on the role of newer technology in the management of the unanticipated difficult airway.	Devices such as the laryngeal mask, lighted styler and rigid fibreoptic laryngoscopes, in the setting of unanticipated difficult airway, are effective in establishing a patent airway, may reduce morbidity and are occasionally lifesaving. Evidence supports their use in this setting as either alternatives to facemask and bag ventilation, when it is inadequate to support oxygenation, or to the direct laryngoscope, when tracheal intubation has failed. Specifically, the laryngeal mask and Combitube(TM) have proved to be effective in establishing and maintaining a patent airway in 'cannot ventilate' situations. The lighted stylet and Bullard (rigid) fibreoptic scope are effective in many instances where the direct laryngoscope has failed to facilitate tracheal intubation.
Jones 2002 (54)	IV	B2	To determine the impact of emergency medicine faculty presence and an airway management protocol on success rates of tracheal intubation in the emergency department	First attempt successful intubation was achieved 46% of the time prior to implementation and 62% post-implementation. Mean time to intubation was 9.2 minutes pre vs 4.6 minutes post-implementation.

Author and Year	Level of Evidence	Quality	Study Question	Summary
Gerich 1998 (125)	IV	B1	To evaluate the efficacy of a rapid sequence intubation protocol without the use of paralytic agents, and to determine the need for cricothyrotomy by using this protocol in trauma patients in the field.	Successful orotracheal intubation (without paralytic agents) on the scene was performed in 373/383 patients (97%). 2 patients (0.5%) arrived at the trauma centre with unrecognized oesophageal intubation. 8 patients underwent cricothyrotomy in the field, six without previous attempts at intubation
Staudinger 1993 (145)	III-2	B1	To evaluate the safety and effectiveness of the Combitube(TM) as used by ICU nurses under medical supervision compared with endotracheal airway established by ICU physicians during CPR.(Medical ICU)	Intubation time was shorter for the Combitube(TM) (P < .001) Blood gases for each device showed comparable results; PaO2 was slightly higher during ventilation with the Combitube(TM) (P < .001). Combitube adequate in lieu of ETT and no complications noted
Kihara 2000 (146)	III-1	A	To examine the intubation success rates, haemodynamic changes, airway complications and postoperative pharyngolaryngeal morbidity between blind and lightwand-guided intubation through the intubating laryngeal mask airway (ASA I-II, no known or predicted difficult airways)	Overall intubation success was similar (blind, 93%; lightwand, 100%, but time to successful intubation was significantly shorter (67 vs. 46 s, p = 0.027) and the number of adjusting manoeuvres was significantly fewer (p = 0.024) in the lightwand group. Oesophageal intubation occurred more frequently in the blind group (18 vs. 0%, p = 0.002). The incidence and severity of mucosal injury, sore throat and hoarseness were similar between the groups.
Asai 2000 (46)	III-1	B1	To assess the ease of fibroscope-assisted tracheal intubation while the patient's head and neck were placed in the neutral or the manual in-line position, and to determine if the intubating laryngeal mask facilitated fiberoptic intubation in these positions.	Fiberoptic scope and lLMA was faster, easier and more successful 85% vs 55% than ETT lLMA with fiberoptic scope excellent when c-spine immobilised c-spine
Sakles 1998 (11)	IV	B1	Retrospective Case Series	610 pts needing intubation by ED. 1% overall needed intubation success rate 98.9% 1.1% failed and had cric 9.3% complication rate 81.4% intubated 1 st attempt

Appendix A: Search Terms use for Medline/Embase/Cochrane

3.0 In the patient with potential cervical spine injury requiring emergency intubation in the resuscitation room, what is the optimal method of achieving a secure airway?

✓ Medline/Embase

1. exp Spinal Injuries/
 2. fractures/ or spinal fractures/
 3. exp Cervical Vertebrae/
 4. 1 or 2 or 3
 5. exp "Wounds and Injuries"/
 6. 4 and 5
 7. exp Intubation, Intratracheal/
 8. anesthesia/ or anesthesia, intratracheal/ or anesthesia, intravenous/
 9. (Rapid adj2 sequence adj2 (intubat\$ or induct\$)).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
 10. 7 or 8 or 9
 11. 4 and 10
 12. 4 and 6
 13. 12 and 10
 14. 11 or 12 or 13
 15. 4 or 6
 16. 11 or 13

✓ Cochrane

1. exp Spinal Injuries/
 2. fractures/ or spinal fractures/
 3. exp Cervical Vertebrae/
 4. 1 or 2 or 3
 5. exp "Wounds and Injuries"/
 6. 4 and 5
 7. exp Intubation, Intratracheal/
 8. anesthesia/ or anesthesia, intratracheal/ or anesthesia, intravenous/
 9. (Rapid adj2 sequence adj2 (intubat\$ or induct\$)).mp. [mp=ti, ab, tx, kw, ct, ot, sh, hw]
 10. 7 or 8 or 9
 11. 4 and 10
 12. 4 and 6
 13. 12 and 10
 14. 11 or 12 or 13
 15. 4 or 6
 16. 11 or 13

4.0 In patients with severe head injury (GCS \leq 8) undergoing emergency intubation in the ED, what are the optimal induction agents to minimise secondary brain injury?

✓ Medline/Embase Search Dates June-October 2003

1. exp Craniocerebral Trauma/
2. head injury.mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
3. 1 or 2
4. Emergencies/ or Intubation, Intratracheal/
5. (rapid adj sequence).mp.

6. exp an?esthetics, intravenous/ or "hypnotics and sedatives"/ or exp neuromuscular blocking agents/
8. Lidocaine/
9. FENTANYL/
10. Narcotics/
11. 8 or 9
12. 4 or 5
13. 6 or 10 or 7
14. 3 and 11 and 12
15. limit 14 to english language
16. from 15 keep 2,6,8,10-11,29-30,35,42,49
17. from 16 keep 1-10
18. 3 and 12
19. 18 and intubation, intratracheal/
20. 19 not 17

✓ Cochrane

1. exp Craniocerebral Trauma/
2. Intubation/ or Emergencies/ or Emergency Treatment/ or Intubation, Intratracheal/
3. (rapid adj sequence).mp. [mp=ti, ab, tx, kw, ct, ot, sh, hw]
4. exp anesthetics, intravenous/ or "hypnotics and sedatives"/ or exp neuromuscular blocking agents/
5. 2 or 3
6. Lidocaine/
7. 4 or 6
8. 1 and 5 and 7
9. Intracranial Hypertension/
10. 7 and 9
11. 8 or 10
12. from 11 keep 1,3,6-8

5.0 In the hypotensive trauma patients requiring emergency intubation

✓ Medline/Embase

1. hypotens\$.mp.
2. (low adj blood adj pressure).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
3. (haemorrhagic adj shock).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
4. (hemorrhagic adj shock).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
5. shock/ or shock, hemorrhagic/ or shock, traumatic/
6. Hypovolemia/
7. 1 or 2 or 3 or 4 or 5 or 6
8. Intubation, Intratracheal/
9. emergency.mp. and 8 [mp=title, abstract, cas registry/ec number word, mesh subject heading]
10. (anaesthe\$ intravenous or anesthe\$ intravenous).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
11. (rapid adj sequence adj induction).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
12. (rapid adj sequence adj intubation).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
13. "Wounds and Injuries"/

14. Anesthesia, Intravenous/
15. 8 or 9 or 14 or 11 or 12
16. 7 and 15
17. 7 and 15 and 13
18. "Hypnotics and Sedatives"/
19. Propofol/
20. Thiopental/
21. KETAMINE/
22. ETOMIDATE/
23. MIDAZOLAM/
24. exp analgesics, opioid/ or narcotics/ or FENTANYL/
25. SUCCINYLCHOLINE/
26. Neuromuscular Blockade/
27. exp Neuromuscular Blocking Agents/
28. vasopressors.mp.
29. epinephrine/ or norepinephrine/
30. sympathomimetics/ or dobutamine/ or ephedrine/ or epinephrine/ or heptaminol/ or metaraminol/ or norepinephrine/
31. 28 or 29 or 30
32. 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27
33. (16 and 31) or (17 and 31)
34. (16 and 32) or (17 and 32)

6.0 In the trauma patient requiring emergency control of the airway, what is the best treatment algorithm to follow for management of a "difficult airway"?

- ✓ Medline/Embase/Cochrane
- 1. INTUBATION/ or INTUBATION, INTRATRACHEAL/
- 2. emergency.mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
- 3. (difficult adj airway).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
- 4. (difficult adj intubation).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
- 5. 3 or 4
- 6. 5 and 2
- 7. 1 and 2
- 8. trauma.mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
- 9. 8 and 7
- 10. 5 and 8
- 11. 9 or 10
- 12. (guidelines or recommendations or options or protocol).mp. [mp=title, abstract, cas registry/ec number word, mesh subject heading]
- 13. 11 and 12
- 14. from 13 keep 2,5,7,9,11-12,14,16
- 15. from 11 keep 6-7,14,28-30,32,41,63,68-73,79,86-87,92,100-102,105,107,149,167,169,181,185-186
- 16. (5 or 6) and 12
- 17. 7 and 12
- 18. 17 or 16 or 14 or 15
- 19. 18
- 20. limit 19 to human

Appendix B: Cricoid Pressure

Purpose:

- Prevention of gastric regurgitation
- Prevention of gastric insufflation during ventilation
- Aid to intubation

Theory:

Avoiding extension of the neck apply backward pressure on the cricoid cartilage. This complete cartilaginous ring transmits pressure to compress the upper oesophagus against the 5th vertebral body. Occlusion of the oesophagus prevents regurgitation of gastric contents and aspiration.

Method:

- In conscious patients the cricoid cartilage is palpated between the thumb and middle finger, with the index finger above.
- The cricoid cartilage is located just below the prominent thyroid cartilage (Adam's apple).
- As anaesthesia is induced the pressure is increased in a vertical plane onto the vertebral body of C5.
- The amount of pressure needs to approximate to 30 Newtons, comparable to the pressure that would feel uncomfortable if applied to the bridge of the nose.
- Removal of cricoid pressure should only follow securing of the airway and the request of the person performing intubation.

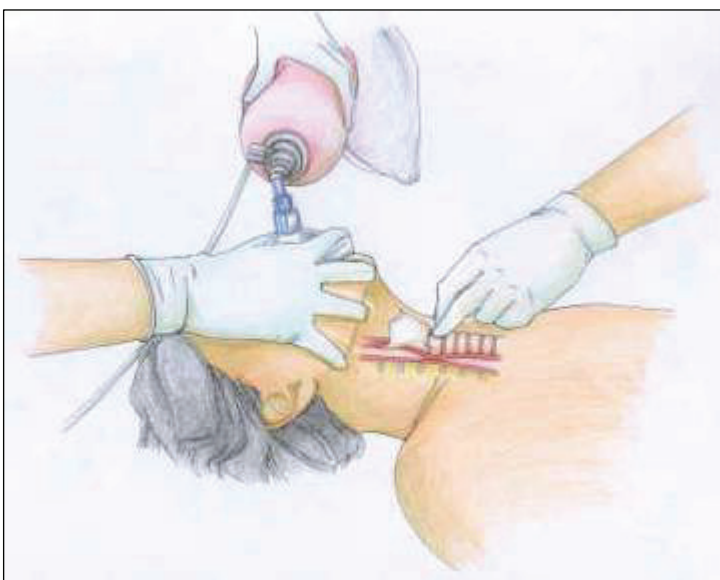
Problems:

1. Cricoid pressure may increase the difficulty of intubation, usually due to incorrect placement. The pressure needs to be applied in the vertical plane in the supine patient to avoid causing tracheal and laryngeal deviation. On request it may be necessary to adjust position or rarely remove cricoid pressure to facilitate intubation.

2. If vomiting occurs, cricoid pressure should be released.

Always ask if you want to remove cricoid pressure and have not been requested to do so.

Figure 1: Cricoid Pressure



Appendix C: Rapid Sequence Induction (RSI) in Trauma

Purpose

To achieve a secure airway, ie a cuffed tube in the trachea, whilst minimising the risk of aspiration of gastric contents in high risk individuals.

Theory

Induction of anaesthesia with a rapid onset sedating agent and neuromuscular blocking agent, application of cricoid pressure, and intubation of the trachea with an oral, cuffed endotracheal tube.

Method

1. Check equipment and draw up drugs. Place wall suction under the pillow by your right hand and ensure a tracheal tube introducer is immediately available. Allocate staff roles (4 experienced personnel required).
2. Loosen or remove anterior portion of the hard cervical collar while maintaining an immobile cervical spine with manual in-line stabilisation of the neck (MILS) ¹.
3. Pre-oxygenate patient for up to 5 minutes or as long as circumstances allow.
4. Rapid administration of induction agent followed by neuromuscular blocking agent and flush through peripheral venous line.
5. Application of cricoid pressure as anaesthesia is induced².
6. When muscle fasciculation has stopped, there is other objective evidence of paralysis, or after 60 seconds, perform laryngoscopy and intubate the trachea^{3,4}.
7. Inflate the ETT cuff and check position of the tube by capnography, visualisation of chest movements, auscultation of bilateral axillae and epigastrium and observation of patient monitoring⁵. Secure the ETT.
8. Remove cricoid pressure on instruction from the intubating physician.
9. Insert naso / orogastric tube.
10. Obtain a CXR to confirm tube position.

Requirements

4 trained staff	Continuous monitoring of HR and
Tight fitting transparent face mask and high flow oxygen	Non-invasive BP
Self inflating bag and mask (selection of sizes)	Pulse oximetry
Selection of laryngoscopes, blades and spare bulbs	Capnography
Selection of endotracheal tubes (ETT)	Wall suction immediately available
Flexible bougie and long stylet	Tie to secure airway
	Drugs drawn up in pre-determined doses
	Saline flush

1. MILS technique is shown in Figure 2 below and described in the main text
2. Cricoid pressure technique described at Appendix B
3. Objective evidence may include use of a nerve stimulator.
4. It is recommended that a flexible bougie is always used in the trauma patient. As a minimal requirement it should be at the right hand of the operator during intubation attempts. A stylet is an optional adjunct.
5. Failure to correctly place the ETT should prompt the operator to follow the “difficult airway management” algorithm provided on page 4.

Figure 2: Manual In-Line Stabilisation (MILS) – *photo courtesy of Trauma Department of Liverpool Hospital.*



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