Emergency intubation for acutely ill and injured patients (Review)

Lecky F, Bryden D, Little R, Tong N, Moulton C

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ABSTRACT

Background

Emergency intubation has been widely advocated as a life saving procedure in severe acute illness and injury associated with real or potential compromises to the patient's airway and ventilation. However, some initial data have suggested a lack of observed benefit.

Objectives

To determine in acutely ill and injured patients who have real or anticipated problems in maintaining an adequate airway whether emergency endotracheal intubation, as opposed to other airway management techniques, improves the outcome in terms of survival, degree of disability at discharge or length of stay and complications occurring in hospital.

Search strategy

We searched the Cochrane Injuries Group Specialised Register (December 2006), Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2006, Issue 4), MEDLINE (1950 to November 2006), EMBASE (1980 to week 50, December 2006), National Research Register (Issue 4, 2006), CINAHL (1980 to December 2006), BIDS (to December 2006) and ICNARC (to December 2006). We also examined reference lists of articles for relevant material and contacted experts in the field. Non-English language publications were searched for and examined.

Selection criteria

All randomised (RCTs) or controlled clinical trials involving the emergency use of endotracheal intubation in the injured or acutely ill patient were examined.

Data collection and analysis

The full texts of 452 studies were reviewed independently by two authors using a standard form. Where the review authors felt a study may be relevant for inclusion in the final review or disagreed, the authors examined the study and a collective decision was made regarding its inclusion or exclusion from the review. The results were not combined in a meta-analysis due to the heterogeneity of patients, practitioners and alternatives to intubation that were used.

Main results

We identified three eligible RCTs carried out in urban environments. Two trials involved adults with non-traumatic out-of-hospital cardiac arrest. One of these trials found a non-significant survival disadvantage in patients randomised to receive a physician-operated intubation versus a combi-tube (RR 0.44, 95% CI 0.09 to 1.99). The second trial detected a non-significant survival disadvantage in patients randomised to paramedic intubation versus an oesophageal gastric airway (RR 0.86, 95% CI 0.39 to 1.90). The third included study was a trial of children requiring airway intervention in the prehospital environment. The results indicated no difference in survival (OR 0.82, 95% CI 0.61 to 1.11) or neurologic outcome (OR 0.87, 95% CI 0.62 to 1.22) between paramedic intubation versus bag-valve-mask ventilation and later hospital intubation by emergency physicians; however, only 42% of the children randomised to paramedic endotracheal intubation actually received it.

Authors' conclusions

The efficacy of emergency intubation as currently practised has not been rigorously studied. The skill level of the operator may be key in determining efficacy.

In non-traumatic cardiac arrest, it is unlikely that intubation carries the same life saving benefit as early defibrillation and bystander cardiopulmonary resuscitation (CPR).

In trauma and paediatric patients, the current evidence base provides no imperative to extend the practice of prehospital intubation in urban systems.

It would be ethical and pertinent to initiate a large, high quality randomised trial comparing the efficacy of competently practised emergency intubation with basic bag-valve-mask manoeuvres (BVM) in urban adult out-of-hospital non-traumatic cardiac arrest.

PLAIN LANGUAGE SUMMARY

Emergency intubation to assist acutely ill and injured patients

Emergency endotracheal intubation (placing a tube through the mouth and throat into the lungs) may reduce deaths from acute illness and injury, but more research is necessary.

Acute illness and injury are the most common causes of death and disability worldwide in people aged under 50 years. The highest priority in an emergency is to enable a patient to breathe by securing their airway (passage from the nose and mouth into the lungs). Endotracheal intubation is one of various ways to secure the airway. This review found no difference between endotracheal intubation and other airway securing strategies for reducing deaths after acute illness or injury; however, better studies are needed.

BACKGROUND

Airway control and adequate respiration is a priority in the management of any seriously ill or injured person (Nolan 2005; Rotondo 1993). If either is impaired, then emergency endotracheal intubation may be performed in order to secure the airway or assist with ventilation. There are a large number of reports which suggest that airway obstruction is present in many trauma patients and contributes to both morbidity and mortality (Gentleman 1981; Hussain 1994). Endotracheal intubation has, therefore, increased in both the prehospital and early emergency room phases of any resuscitation attempt (Regel 1995).

The use of early intubation is a practice that has resulted in a reduction in morbidity for some groups of patients, most notably those with moderate to severe head injuries (Gildenberg 1985). In this group of patients the wider use of endotracheal intubation and control of ventilation can reduce the incidence of secondary cerebral insults that contribute significantly to morbidity and mortality (Gentleman 1992). Intubation of the trachea is a procedure that is associated with significant risks, including the dangers of aspiration of gastric contents and blood, unrecognised oesophageal intubation and aggravation of existing traumatic injuries such as cervical spine damage. It also usually requires the administration of drugs, which may have a detrimental effect on other organs, for example the heart. Despite these risks the use of endotracheal intubation in the resuscitation of a severely injured patient has been said to have a low morbidity (Rotondo 1993).

Recent data collected from both Europe and the USA, however, suggest that endotracheal intubation may not be universally beneficial in all seriously ill and injured patients. Unadjusted data from Belgium, examining 953 out-of-hospital emergencies, including trauma cases, where individuals received cardiopulmonary resuscitation at the scene, suggests that survival to reach hospital was higher in those who were not intubated before arrival than those who were (89.5% versus 67.6%) (Stamatakis 1995). Evidence from data collected by the United Kingdom Trauma Audit Research Network (UK TARN), when adjusted for Injury Severity Score and Revised Trauma Score, also suggests an association between outcome and emergency intubation. Seriously injured patients with an initial Glasgow Coma Score of eight or less who were intubated prior to arrival at hospital or on arrival to the emergency department had a lower 30-day survival than those who were not intubated (46.6% versus 69.3%) (UK TARN 1996). Furthermore, in support of the European evidence, a study of a large group of matched patients by the American College of Surgeons suggests that there is no difference in mortality between those who received emergency intubation in the emergency department and those who did not (Copes 1995).

Much of this data is uncontrolled and may reflect other unconsidered variables , for example the practice of individuals who are not expert in airway management to intubate only certain selected groups of patients. However, there is enough evidence to suggest that a review of the practice of emergency endotracheal intubation in the early phase of a resuscitation attempt is warranted.

OBJECTIVES

To determine in acutely ill or injured patients, who have real or anticipated problems in maintaining an adequate airway, whether endotracheal intubation compared to other airway management methods improves outcome in terms of:
a) reduction in hospital mortality or disability on leaving hospital;
b) reduction in the incidence of the following complications: aspiration pneumonia, multiple organ failure, cervical spine injury, length of hospital stay.
Other airway management techniques include bag valve mask ventilation with or without an airway adjunct, combi-tube, oesophageal gastric airway and laryngeal mask.

(The Combi-tube is a double lumen tube with one blind end which functions as an oesophageal obturator airway and the other as a standard cuffed endotracheal tube. It is inserted blindly into the mouth and seals the oral and nasopharyngeal cavities.)

CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

Types of studies

All randomised trials or controlled trials involving the emergency use of endotracheal intubation in the injured or acutely ill patient.

Types of participants

Patients of any age who were injured or acutely ill for other reasons and presented to a hospital emergency room. Studies involving acute deterioration in adults with longstanding respiratory disease were excluded as these have already been the subject of a Cochrane review (Ram 2004).

Types of intervention

Intubation was defined as endotracheal intubation of the patient in the prehospital or emergency department setting. Intubation can be performed for the following reasons:
a) securing the patient's airway,
b) control of ventilation,
c) to optimise therapy and minimise the effects of secondary brain injury in individuals with a head injury and a Glasgow Coma Score of eight or less, and
d) to prevent combative behaviour and facilitate further examination.
It did not include endotracheal intubation performed to facilitate emergency surgery.
Endotracheal intubation may or may not have been accompanied by prior administration of anaesthetic, sedative or paralysing agents; and may or may not have been succeeded by positive pressure ventilation.

Types of outcome measures

The primary outcome measures were all-cause mortality, namely death either before arrival to hospital or at discharge; and degree of disability at discharge from hospital. Disability measures included assessment of Glasgow Outcome Scale score or an equivalent measure if this was not available.

Secondary outcomes were measures of morbidity, such as:
a) the incidence of pulmonary complications including evidence of aspiration, pneumonia or atelectasis during hospital stay,
b) the incidence of documented cervical spine injury,
c) the incidence of and number of organs affected by multiple organ failure,
d) the length of stay in hospital and length of stay on the intensive care unit, where appropriate.

SEARCH METHODS FOR IDENTIFICATION OF STUDIES

See: Cochrane Injuries Group methods used in reviews.

We searched the following electronic databases:

- Cochrane Injuries Group Specialised Register (searched 19 December 2006);
- Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2006, Issue 4);
- MEDLINE (1950 to November (week 3) 2006);
- EMBASE (1980 to week 50, December 2006);
- CINAHL (to December 2006);
- National Research Register (Issue 4, 2006);
- BIDS (December 2006);
- ICNARC (December 2006);
- Zetoc (searched 19 December 2006).

The full search strategies used to search CENTRAL, MEDLINE, EMBASE and National Research Register (NRR) are presented in Table 01. The searches of all other databases were based on these strategies.
We searched the internet, checked the reference lists of relevant studies and, where possible, contacted the first author of each included study to identify further potentially eligible studies.

The searches were not restricted by publication status, date or language.

METHODS OF THE REVIEW

Trial identification and selection

Two authors independently examined titles, abstracts and keywords of citations from electronic databases for eligibility. We obtained the full text of all relevant records and the two authors independently assessed whether each met the predefined inclusion criteria. We resolved disagreement by discussion.

Data extraction
Data were extracted independently by two authors.

Assessment of methodological quality
Trials were examined for evidence of adequacy of randomisation, allocation concealment and follow up.

Allocation concealment was evaluated against Cochrane criteria as described by Higgins 2005:
Grade A: adequate allocation concealment.
Grade B: unclear, not described in the paper or could not be verified by contacting the authors.
Grade C: inadequate allocation concealment.
Grade D: allocation concealment was not used.

Where the method used to conceal allocation was not clearly reported, the study author(s) were contacted, when possible, for clarification.

Data analysis
The results from the included studies were not combined in a meta-analysis due to the heterogeneity of patients, practitioners and the alternatives to intubation that were used.

DESCRIPTION OF STUDIES

The combined search strategy identified 13,000 articles of which the full text of 452 were obtained.

We identified three eligible RCTs, each of which was conducted in an urban setting with short prehospital to hospital transit times (Gausche 2000; Goldenberg 1986; Rabitsch 2003).
There were no controlled trials or observational studies eligible for inclusion.

Gausche 2000
This trial compared paramedic endotracheal intubation (ETI) versus bag-valve-mask ventilation (BVM) and later physician emergency department (ED) ETI in 830 children, aged 13 years and under, who presented with a variety of prehospital aetiologies requiring airway intervention. Seventy-one per cent of the children had suffered a non-traumatic out-of-hospital (OOH) cardiac arrest, 13% a respiratory arrest, 8% status epilepticus and the remainder had mainly a traumatic coma aetiology. Drugs were not available to assist the paramedic ETI. The outcome measures were survival and neurologic outcome at acute hospital discharge.

Goldenberg 1986
This trial compared paramedic-operated ETI versus an oesophageal gastric tube airway (EGTA) in 175 adult non-traumatic out-of-hospital cardiac arrest patients. The main outcome measure was survival to hospital discharge.

Rabitsch 2003
This trial compared physician-operated ETI with a combi-tube in 172 adult non-traumatic out-of-hospital cardiac arrest patients. The main outcome measure was survival to hospital discharge.

Further details are presented in the 'Characteristics of included studies' table.

Excluded studies
We identified a number of relevant observational studies. Each is described in detail in the table 'Characteristics of excluded studies'. Other reviewed studies were excluded due to a lack of relevance to the review objectives in terms of the interventions performed or the outcomes considered. Examples of these, along with the review authors' comments, are also in the excluded studies.

METHODOLOGICAL QUALITY

Gausche 2000
This trial allocated paediatric patients to receive either paramedic ETI or BVM and later ED physician ETI by calendar day (odd or even). Age, gender, aetiologies for airway intervention and the proportion of children not further resuscitated at the ED were equivalent between the two randomised groups. However, within each aetiology there was no further breakdown of confounders (presenting rhythm for cardiac arrest, Glasgow Coma Score in other groups) other than that the proportion of children in cardiac arrest receiving bystander cardio-pulmonary resuscitation (CPR) was equivalent between the allocated trial groups. ETI was not attempted in 27% of patients randomised to receive it and, where attempted, the success rate was 57% (resulting in successful ETI in 42% of children allocated to receive it). The results were analysed on an intention-to-treat basis and an actual airway-received basis. It is possible that a percentage of those receiving BVM did not receive ED ETI as 5% of this group went from the ED to a hospital ward or home. Follow up was continued until discharge for survival and neurologic outcomes; there were 10 (1%) losses to follow up. Children were blinded to trial allocation, those performing airway care were not. The outcome assessors were not blinded to allocation but independently reviewed each outcome. The two assessors weighted kappa outcomes had very good agreement (k = 0.978 (0.93 to 1.0)). Allocation concealment was graded D.

Goldenberg 1986
This trial randomised consecutive adult OOH cardiac arrest patients to two interventions (ETI or EGTA) by means of random number generated cards. It was unclear whether or not the groups were equivalent in terms of numbers of shocks for ventricular fibrillation (VF) patients but equivalence for other confounders was demonstrated. A significant proportion (17%) of patients received the opposite airway intervention from that to which they had

been randomised, due to technical difficulties; but an intention-to-treat analysis was presented. It was unclear what proportion of EGTA patients subsequently received ETI in the ED. Patients were followed up to hospital discharge in order to determine survival, which was the main outcome measure; there appeared to have been no losses to follow up. Patients were blinded to trial allocation, those performing airway interventions were not. It was unclear whether or not the outcome assessors were blinded (Grade B allocation concealment).

Rabitsch 2003
This trial allocated consecutive adult OOH cardiac arrest patients presenting to the EMS by calendar day (odd or even) to physician-operated ETI versus a combi-tube. Combi-tube patients were 40% more likely to have received bystander CPR at the arrest scene (8% versus 11%) but appeared similar in terms of other confounders. Three per cent of patients received the opposite intervention from that to which they had been allocated due to technical difficulties, however results were analysed on an intention-to-treat basis. It was unclear what proportion of combi-tube patients subsequently received ETI in the ED. Patients were followed up until hospital discharge in order to determine survival, which was the main outcome measure. There appeared to have been no losses to follow up. Patients were blinded to trial allocation, those performing airway interventions were not. The outcome assessors were blinded to trial allocation group (Grade D allocation concealment).

RESULTS

Gausche 2000
This trial compared paramedic ETI versus paramedic BVM and ED physician ETI in paediatric patients requiring prehospital airway intervention from a variety of aetiologies. The results indicated that there was no survival (26% versus 30%; OR 0.82, 95% CI 0.61 to 1.11) or good neurologic outcome (23% versus 20%; OR 0.87, 95% CI 0.62 to 1.22) advantage in children randomised to receive ETI versus BVM and later ED ETI should resuscitation be continued. This was an intention-to-treat analysis where only 42% of the group randomised actually received paramedic ETI. There was no difference in the hospital length of stay between survivors in the two groups.

Goldenberg 1986
This trial compared paramedic-operated ETI versus EGTA in adults with out-of-hospital non-traumatic cardiac arrest. The results indicated a small non-significant difference in survival to hospital discharge in an intention-to-treat analysis of 175 patients (11.1% ETI versus 12.9% EGTA). Relative risk of survival with ETI was 0.86 (98% CI 0.39 to 1.90). Seventeen per cent of patients had different airway interventions from those for which they were randomised. When adjusted for, this widened the outcome difference (10.9 versus 15.4%) but the study was not powered to show this difference as significant. The reported insertion success and adequacy of ventilation rates were similar (90% versus 90% for insertion, 90% ETI versus 70 to 90% EGTA for ventilation).

Rabitsch 2003
This randomised trial compared physician-operated ETI versus a combi-tube in adults with out-of-hospital non-traumatic cardiac arrest. A doubling of survival to hospital discharge was demonstrated in the combi-tube group (ETI 3% versus combi-tube 6%) with similar insertion success rates (94% versus 98%). The sample number of 172 patients was insufficient to show this difference as significant; relative risk of survival with ETI was 0.43 (95% CI 0.09 to 1.99). The pulmonary aspiration rate was 2% in the combi-tube group, 0% with ETI.

DISCUSSION

This review identified three trials that examined the efficacy of ETI compared to alternative airway management techniques in the prehospital setting. No single study showed a statistically significant difference in outcome between the treatment groups. Two trials were conducted in adult out-of-hospital non-traumatic cardiac arrest patients (Goldenberg 1986; Rabitsch 2003) and one in paediatric patients with traumatic and medical reasons for airway control (Gausche 2000). Each trial employed different alternatives to ETI (EGTA, combi-tube, BVM). Paramedics managed the airway in two trials (Gausche 2000; Goldenberg 1986), physicians in the third trial (Rabitsch 2003). We did not combine the results of these studies due to the heterogeneity of patient groups, airway operators and alternatives to ETI.

In considering the implications of this finding it must be acknowledged that these trials do not constitute definitive evidence. Two trials were carried out in adult OOH cardiac arrest victims, however, neither was of sufficient power to show the differences found to be significant. The third trial in paediatric out-of-hospital emergencies was sufficiently powered however ETI was not carried out in the majority of the children randomised to receive it, raising questions about inclusion criteria in relation to operator (paramedic) training and perceptions. The success rates when ETI was attempted by paramedics were much lower than desirable, 57% (Gausche 2000) and 90% (Goldenberg 1986) compared to 94% with physicians (Rabitsch 2003), suggesting that the skill of the operator and operating conditions may be key in determining the efficacy of ETI. The relevant secondary outcomes identified (complications, rates of multiorgan failure) are not comprehensively addressed by the trials. There are some questions relating to confounding in each trial. Finally, the design of all three trials relates only to prehospital care in an urban setting.

Research in the emergency setting has particular difficulties in terms of the pressure of time and ethical issues pertaining to consent. This perhaps explains the paucity of trials compared to the large amount of observational data published in relation to the efficacy of emergency ETI. The review may be criticised for excluding these studies, however each observational study found was considered carefully by the review authors. Nine observational studies were identified that contained data, five of which were prospective (Callaham 1996; Geehr 1985; Hillis 1993; Rainer 1997; Shea 1985) and examined the efficacy of paramedic ETI in adult non-traumatic out-of-hospital cardiac arrest when compared to a range of airway alternatives (EGTA, BVM). Two prospective studies contained data relating to the efficacy of ETI in an adult in-hospital non-traumatic cardiac arrest population (King 1994; Marwick 1991). Some of these studies are much larger than the trials considered in the review and show results that are significant. However, the review group felt each had particular flaws in terms of failure to adjust for important confounders or missing data that made the results less reliable than the included trials.

Similarly in adult trauma patients, 18 observational studies with four prospective (Bochicchio 2003; Davis 2003; Trupka 1995; Westhoff 2002) were found comparing ETI usually to BVM. The majority (13) of these studies related to the timing of ETI (prehospital 'early' (paramedic in some cases) versus 'late' with prehospital paramedic BVM and physician ED ETI) in heterogeneous groups of trauma patients. The remainder examined practice purely in the emergency department or the prehospital environment. One retrospective study examined ETI in adult hypothermia patients. The results of these studies were often significant but different studies with similar conduct and inclusion criteria reached contradictory findings. Once again the review group found issues with missing data and confounding that impacted on the reliability of results; this was often in line with the authors' own discussions. Hence each study was excluded but is described fully in the excluded studies table.

At this time, having considered the included trials and other evidence, the review group suggest that currently there is insufficient high quality data available to comment on the efficacy of emergency ETI, an intervention often advocated as life saving.

AUTHORS' CONCLUSIONS

Implications for practice

Clinicians need to establish a safe airway and adequate ventilation for patients in emergency situations bearing in mind that the efficacy of emergency endotracheal intubation, as currently practised, has not been rigorously studied.

The skill of the operator may be a key determinant of efficacy in all patient groups. Success rates are not reported in most studies and in paramedic studies to date those quoted are often less than desirable (< 95% after three attempts), which may reflect skill retention and operating conditions.
In non-traumatic cardiac arrest it is unlikely that intubation carries the same life saving benefit as early defibrillation and bystander CPR.

In paediatric and trauma patients the current evidence base provides no imperative to extend the practice of prehospital intubation in urban and short transit time systems.

Implications for research

Given the review findings and the large investment in paramedic intubation training, it would seem ethical to initiate a large, high quality randomised trial comparing ETI efficacy (involving competent practitioners) to basic manoeuvres (BVM) in urban out-of-hospital adult cardiac arrest. The findings of this trial would then determine the nature of future studies in trauma patients and other groups.

POTENTIAL CONFLICT OF INTEREST

None known.

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REFERENCES

References to studies included in this review

Gausche 2000 *{published and unpublished data}*
Gausche M, Lewis RJ, Stratton SJ, Haynes BE, Gunter CS, Goodrich SM, et al.Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial. *JAMA* 2000;**9**(283):783–90.

Goldenberg 1986 *{published data only}*
Goldenberg IF, Campion BC, Siebold CM, McBride JW, Long LA. Esophageal gastric tube airway vs endotracheal tube in prehospital cardiopulmonary arrest. *Chest* 1986;**90**(1):90–6.

Rabitsch 2003 *{unpublished data only}*
Rabitsch W, Schellongowski P, Staudinger T, Hofbauer R, Dufek V, Eder B, et al.Comparison of a conventional tracheal airway with the Combitube in an urban emergency medical services system run by physicians. *Resuscitation* 2003;**57**(1):27–32.

References to studies excluded from this review

Abbott 1998
Abbott D, Brauer K, Hutton K, Rosen P. Aggressive out-of-hospital treatment regimen for severe closed head injury in patients undergoing air medical transport. *Air Medical Journal* 1998;**17**(3):94–100.

Adams 1997
Adams JN, Sirel J, Marsden K, Cobbe SM. Heartstart Scotland: the use of paramedic skills in out of hospital resuscitation. *Heart* 1997;**4**(78):399–402.

Atherton 1993
Atherton GL, Johnson JC. Ability of paramedics to use the COMBITUBE in prehospital cardiac arrest. *Annals of Emergency Medicine* 1993;**22**:1263–8.

Auerbach 1983
Auerbach PS, Geehr EC. Inadequate oxygenation and ventilation using the esophageal gastric tube airway in the prehospital setting. *JAMA* 1983;**250**:3067–71.

Aufderheide 1994
Aufderheide TP, Aprahamian C, Mateer JR, Rudnick E, Manchester EM, Lawrence SW, et al.Emergency airway management in hanging victims. *Annals of Emergency Medicine* 1994;**24**:879–84.

Bochicchio 2003
Bochicchio GV, Ilahi O, Joshi M, Bochicchio K, Scalea TM. Endotracheal intubation in the field does not improve outcome in trauma patients who present without an acutely lethal traumatic brain injury. *Journal of Trauma - Injury Infection & Critical Care* 2003;**54**(2):307–11.

Broos 1993
Broos PLO, D'Hoore A, Vanderschot P, Rommens PM, Stappaerts KH. Multiple trauma in elderly patients. Factors influencing outcome: Importance of aggressive care. *Injury* 1993;**24**(6):365–8.

Buchmann 1992
Buchmann B, Kaufmann MA, Scheidegger D, Gratzl O. Does on-scene resuscitation affect in-hospital 'do not resuscitate' decisions and mortality in patients with severe head injuries?. *Journal of Trauma* 1992;**32**(4):459–63.

Bur 2001
Bur A, Kittler H, Sterz F, Holzer M, Eisenburger P, Oschatz E, et al.Effects of bystander first aid, defibrillation and advanced life support on neurologic outcome and hospital costs in patients after ventricular fibrillation cardiac arrest. *Intensive Care Medicine* 2001;**27**(9):1474–80.

Calkins 1999
Calkins MD, Robinson TD. Combat trauma airway management: endotracheal intubation versus laryngeal mask airway versus combitube use by Navy Seal and Reconnaissance combat corpsmen. *Journal of Trauma* 1999;**46**:927–32.

Callaham 1996
Callaham M, Madsen CD. Relationship of timeliness of paramedic advanced life support interventions to outcome in out-of-hospital cardiac arrest treated by first responders with defibrillators. *Annals of Emergency Medicine* 1996;**27**(5):638–48.

Danzl 1989
Danzl DF, Hedges JR, Pozos RS. Hypothermia outcome score: Development and implications. *Critical Care Medicine* 1989;**17**(3):227–31.

Davis 2003
Davis DP, Hoyt DB, Ochs M, Fortlage D, Holbrook T, Marshall LK, et al.The effect of paramedic rapid sequence intubation on outcome in patients with severe traumatic brain injury. *Journal of Trauma - Injury Infection & Critical Care* 2003 Mar;**54**(3):444–53.

Don Michael 1985
Don Michael TA. Comparison of the esophageal obturator airway and endotracheal intubation in prehospital ventilation during CPR. *Chest* 1985;**87**(6):814–9.

Durham 1992
Durham LA, Richardson RJ, Wall MJ, Pepe PE, Mattox KL. Emergency center thoracotomy: impact of prehospital resuscitation. *The Journal of Trauma* 1992;**32**(6):775–9.

Eckstein 2000
Eckstein M, Chan L, Schneir A, Palmer R. Effect of prehospital advanced life support on outcomes of major trauma patients. *Journal of Trauma - Injury Infection & Critical Care* 2000;**48**(4):643–8.

Fortune 1997
Fortune JB, Judkins DJ, Stanzaroli D, McLeod KB, Johnson SB, Davis FE, et al.Efficacy of prehospital surgical cricothyrotomy in trauma patients. *Journal of Trauma* 1997;**42**:832–8.

Frankel 1997
Frankel H, Rozycki G, Champion H, Harviel JD, Bass R. The use of TRISS methodology to validate prehospital intubation by urban EMS providers. *American Journal of Emergency Medicine* 1997;**15**(7):630–2.

Garner 1999
Garner A, Rachford S, Lee A, Bartolacci R. Addition of physicians to paramedic helicopter services decreases blunt trauma mortality. *The Australian and New Zealand Journal of Surgery* 1999;**69**(10):697–701.

Garner 2001
Garner A, Crooks J, Lee A, Bishop R. Efficacy of prehospital critical care teams for severe blunt head injury in the Australian setting. *Injury* 2001;**32**(6):455–60.

Geehr 1985
Geehr EC, Bogetz MS, Auerbach PS. Pre-hospital tracheal intubation versus esophageal gastric tube airway use: A prospective study. *American Journal of Emergency Medicine* 1985;**3**(5):381–5.

Gordon 1995
Gordon E, von Holst H, Rudehill A. Outcome of head injury in 2298 patients treated in a single clinic during a 21-year period. *Journal of Neurosurgical Anesthesiology* 1995;**7**(4):235–47.

Hammargren 1985
Hammargren Y, Clinton JE, Ruiz E. A standard comparison of esophageal obturator airway and endotracheal tube ventilation in cardiac arrest. *Annals of Emergency Medicine* 1985;**14**(10):953–8.

Hedges 2002
Hedges JR, Adams AL, Gunnels MD. ATLS practices and survival at rural level III trauma hospital, 1995-1999. *Prehospital Emergency Care* 2002;**6**(3):299–305.

Hillis 1993
Hillis M, Sinclair D, Butler G, Cain E. Prehospital cardiac arrest survival and neurologic recovery. *Journal of Emergency Medicine* 1993; **11**(3):245–52.

Holmberg 2002
Holmberg M, Holmberg S, Herlitz J. Low chance of survival among patients requiring adrenaline (epinephrine) or intubation after out-of-hospital cardiac arrest in Sweden. *Resuscitation* 2002;**54**(1):37–45.

Huf 1996
Huf R, Kraft S, Schildberg FW. The time of intubation and its effect on the clinical course of polytraumatized patients with pulmonary contusion [Der Einfluss des Intubationszeitpunktes auf den klinischen Verlauf polytraumatisierter Patienten mit Lungenkontusion]. *Zentralblatt fur Chirurgie* 1996;**121**(1):21–3.

Karch 1996
Karch S. Field intubation of trauma patients: complications, indications and outcomes. *American Journal of Emergency Medicine* 1996; **14**:617–9.

King 1994
King D, Davies KN, Cope CS, Silas JH. Survey of cardiac arrests and cardiac arrest trolleys in a district general hospital. Survey of cardiac arrests and cardiac arrest trolleys in a district general hospital. *British Journal of Clinical Practice* 1994;**48**(5):248–50.

Kuchinski 1991
Kuchinski J, Tinkoff G, Rhodes M, Becher Jr JW. Emergency intubation for paralysis of the uncooperative trauma patient. *Journal of Emergency Medicine* 1991;**9**(1-2):9–12.

Liberman 2000
Liberman M, Mulder D, Sampalis J. Advanced or basic life support for trauma: meta-analysis and critical review of the literature. *Journal of Trauma - Injury Infection & Critical Care* 2000;**49**(4):548–99.

Marwick 1991
Marwick TH, Case CC, Siskind V, Woodhouse SP. Prediction of survival from resuscitation: a prognostic index derived from multivariate logistic model analysis. *Resuscitation* 1991;**22**(2):129–37.

Murray 2000
Murray JA, Demetriades D, Berne TV, Stratton SJ, Cryer HG, Bongard F, et al.Prehospital intubation in patients with severe head injury. *Journal of Trauma - Injury Infection & Critical Care* 2000;**49**(6): 1065–70.

Norwood 1994
Norwood S, Myers MB, Butler TJ. The safety of emergency neuromuscular blockade and orotracheal intubation in the acutely injured trauma patient. *Journal of the American College of Surgeons* 1994;**179**: 646–52.

Orliaguet 1997
Orliaguet GA, Tartiere S, Lejay M, Carli PA. A prospective in-field evaluation of orotracheal intubation by emergency medical services physicians. *Jeur* 1997;**10**:27–32.

Oswalt 1992
Oswalt JL, Hedges JR, Soifer BE, Lowe DK. Analysis of trauma intubations. *American Journal of Emergency Medicine* 1992;**10**(6): 511–4.

Pointer 1988
Pointer JE. Clinical characteristics of paramedics' performance of endotracheal intubation. *Journal of Emergency Medicine* 1988;**6**(6): 505–9.

Rainer 1997
Rainer TH, Marshall R, Cusack S. Paramedics, technicians, and survival from out of hospital cardiac arrest. *Journal of Accident & Emergency Medicine* 1997;**14**(5):278–82.

Regel 1997
Regel G, Stalp M, Lehmann U, Seekamp A. Prehospital care, importance of early intervention on outcome. *Acta Anaestheiologica Scandinavica (Supplementum)* 1997;**110**:71–6.

Rhee 1994
Rhee K, O'Malley R. Neuromuscular blockade-assisted oral intubation versus nasotracheal intubation in the prehospital care of injured patients. *Ann Emerg Med* 1994;**23**:37–42.

Ruchholtz 2002
Ruchholtz S, Waydhas C, Ose C, Lewan U, Nast-Kolb D. The Working Group on Multiple Trauma of the German Trauma Society. Prehospital intubation in severe thoracic trauma without respiratory insufficiency: a matched-pair analysis based on the Trauma Registry of the German Trauma Society. *Journal of Trauma - Injury Infection & Critical Care* 2002;**52**(5):879–86.

Rumball 1997
Rumball CJ, MacDonald D. The PTL, Combitube, laryngeal mask, and oral airway: a randomized prehospital comparative study of ventilatory device effectiveness and cost-effectiveness in 470 cases of cardiorespiratory arrest. *Prehospital Emergency Care* 1997;**1**:1–10.

Sanson 1999
Sanson G, Di Bartolomeo S, Nardi G, Albanese P, Diani A, Raffin L, et al.Road traffic accidents with vehicular entrapment: incidence of major injuries and need for advanced life support. *European Journal of Emergency Medicine* 1999;**6**(4):285–91.

Schmidt 1992
Schmidt U, Frame SB, Nerlich ML, Rowe DW, Enderson BL, Maull KI, et al.On-scene helicopter transport of patients with multiple injuries - Comparison of a German and an American system. *Journal of Trauma* 1992;**33**(4):548–55.

Schneider 1995
Schneider T, Mauer D, Diehl P, Eberle B, Dick W. Does standardized mega-code training improve the quality of prehospital advanced cardiac life support (ACLS)?. *Resuscitation* 1995;**29**:129–34.

Shea 1985
Shea SR, MacDonald JR, Gruzinski G. Prehospital endotracheal tube airway or esophageal gastric tube airway: A critical comparison. *Annals of Emergency Medicine* 1985;**14**:2102–12.

Sloane 2000
Sloane C, Vilke GM, Chan TC, Hayden SR, Hoyt DB, Rosen P. Rapid sequence intubation in the field versus hospital in trauma patients. *Journal of Emergency Medicine* 2000;**19**(3):259–64.

Staudinger 1994
Staudinger T, Brugger S, Roggla M, Rintelen C, Atherton GL, Johnson JC, Frass M. Comparison of the Combitube with the endotracheal tube in cardiopulmonary resuscitation in the prehospital phase [Vergleich des Combitube mit dem Endotrachealtubus wahrend kardiopulmonaler Reanimation in der Prahospitalphase]. *Wiener Klinische Wochenschrift* 1994;**106**(13):412–5.

Stratton 1998
Stratton S, Niemann JT. Effects of adding links to 'the chain of survival' for prehospital cardiac arrest: A contrast in outcomes in 1975 and 1995 at a single institution. *Annals of Emergency Medicine* 1998;**31**(4):471–7.

Tanigawa 1998
Tanigawa K, Shigematsu A. Choice of airway devices for 12,020 cases of nontraumatic cardiac arrest in Japan. *Prehospital Emergency Care* 1998;**2**:96–100.

Trupka 1995
Trupka A, Waydhas C, Nast-Kolb D, Schweiberer L. Effect of early intubation on the reduction of post-traumatic organ failure [Der Einfluss der Frunintubation auf die Reduktion des posttraumatischen]. *Unfallchirurg* 1995;**98**(3):111–7.

Wald 1993
Wald SL, Shackford SR, Fenwick J. The effect of secondary insults on mortality and long-term disability after severe head injury in a rural region without a trauma system. *Journal of Trauma - Injury Infection & Critical Care* 1993;**34**(3):377–81.

Westhoff 2002
Westhoff J, Kalicke T, Muhr G, Kutscha-lissberg F. Die Wirklichkeit der praklinischen Versorgung des Thoraxtraumas - Ergebnisse einer prospektiven Studie [The reality of preclinical treatment in thoracic trauma - a prospective study]. *Anasthesiologie, Intensivmedizin, Notfallmedizin, Schmerztherapie July* 2002;**37**(7):395–402.

Winchell 1997
Winchell RJ, Hoyt DB. Endotracheal intubation in the field improves survival in patients with severe head injury. *Archives of Surgery* 1997;**32**(6):592–7.

Xeropotamos 1993
Xeropotamos NS, Coats TJ, Wilson AW. Prehospital surgical airway management: 1 year's experience from the Helicopter Emergency Medical Service. *Injury* 1993;**24**:222–4.

Additional references

Copes 1995
Copes WS, Forrester C, Konvolinka CW, Sacco WJ. American College of Surgeons Audit Filters: Associations with patient outcome and resource utilisation. *Journal of Trauma, Injury, Infection and Critical Care* 1995;**38**(3):432–8.

Gentleman 1981
Gentleman D, Jennett B. Hazards of Inter-hospital transfer of comatose head-injured patients. *The Lancet* 1981;**ii**:853–5.

Gentleman 1992
Gentleman D. Causes and effects of systemic complications among severely head-injured patients transferred to a neurosurgical unit. *International Surgery* 1992;**77**:297–302.

Gildenberg 1985
Gildenberg PL, Makela M. *The effect of early intubation and ventilation on outcome following head trauma*. New York: Raven Press, 1995.

Higgins 2005
Higgins JPT, Green S, editors. Assessment of study quality. Cochrane Reviewers' Handbook 4.2.5 [updated May 2005]; Section 6. The Cochrane Library 2005; Vol. 3.

Hussain 1994
Hussain LM, Redmond AD. Are pre-hospital deaths from accidental injury preventable?. *BMJ* 1994;**308**:1077–80.

Nolan 2005
Nolan JP, Deakin CD, Soar J, Bottiger BW, Smith G. European Resuscitation Council guidelines 2005. *Resuscitation* 2005;**67 Suppl 1**:39–86.

Ram 2004
Ram FSF, Picot J, LIghtowler J, Wedzicha JA. Non invasive positive pressure ventilation for treatment of respiratory failure due to exacerbation of chronic obstructive pulmonary disease. *Cochrane Database of Systematic Reviews* 2004, Issue 3.

Regel 1995
Regel G, Lobenhoffer P, Grotz M, Pape HC, Lehmann U, Tscherne H. Treatment results of patients with multiple traumas: An analysis of 3406 cases treated between 1972 and 1991 at a German Level 1 Trauma Center. *Journal of Trauma, Injury, Infection and Critical Care* 1995;**38**(1):70–7.

Rotondo 1993
Rotondo MF, McGonigal MD, Schwab CW, Kauder DR, Hanson CW. Urgent paralysis and intubation of trauma patients: Is it safe?. *Journal of Trauma* 1993;**34**(2):242–6.

Stamatakis 1995
Stamatakis L, Daminet B, Tasiaux M, Toussaint B, Gillet JB. In: BES-DEMBSfDaEM editor(s). *Congres des SAMU*. Angouleme: 1995.

UK TARN 1996
United Kingdom Trauma and Audit Research Network. Major Trauma Outcome Study (MTOS). National Conference 1996.

TABLES

Characteristics of included studies

Study	Gausche 2000
Methods	Randomised controlled trial.
Participants	830 patients aged <12 years requiring OOH airway management from a variety of aetiologies. 2 EMS and >22 hospital centres.
Interventions	Paramedic prehospital ETI (no drugs) versus BVM and later ED ETI if resuscitation continued.
Outcomes	Odds of survival and neurological status (Paediatric Cerebral Performance Category scale) at hospital discharge.
Notes	Intention-to-treat analysis. Groups randomised by calendar date (odd, even). Outcome assessors not blinded. 71% patients had non-traumatic OOH cardiac arrest. 13% respiratory arrest, 8% status epilepticus, rest mainly traumatic coma aetiology. Groups. 32% of whole sample not further resuscitated in ED. Similar breakdown in both groups. No attempt at ETI in 27% of those randomised to receive it. 57% success rate for attempted ETI. Secondary analysis by actual intervention suggests ETI harmful (non-equivalent groups). Time to airway intervention similar in both groups and transit times 5 minutes.
Allocation concealment	D – Not used

Study	Goldenberg 1986
Methods	Randomised controlled trial.
Participants	175 OOH non-traumatic cardiac arrest patients. Single EMS and hospital.
Interventions	Paramedic ETI versus paramedic EGTA. Crossed over to alternative device if failed twice with the original.
Outcomes	Survival to hospital discharge.
Notes	Intention-to-treat result however 17% had different airway to initial randomisation. Differences persist and are larger if analysed by actual airway received: 10.9 vs 15.4%. No of shocks for VF patients in randomised groups not given. Non-randomised control group n=125 (EOA) offered by authors survival 12% (ns) although response times shorter and bystander CPR more likely than in ETI, EGTA: (16% vs 13% vs 14 %). Success rates 90% for ETI and EGTA. Transit times < 15 minutes.
Allocation concealment	B – Unclear

Study	Rabitsch 2003
Methods	Randomised controlled trial.
Participants	172 OOH non-traumatic cardiac arrest patients. Single EMS and hospital centre.
Interventions	Physician ETI versus physician combi-tube.
Outcomes	Survival to hospital discharge.
Notes	Intention-to-treat analysis used with 3% patients having different airway to initial randomisation. combi group 1.4 times more likely to get bystander CPR (8% vs 11%). No data comparing time to defibrillation. Success rates 94% ETI, 98% combi. Transit times < 10 minutes.
Allocation concealment	D – Not used

Characteristics of excluded studies

Study	Reason for exclusion
Abbott 1998	Study of prehospital ALS in closed head injury patients: helicopter crew versus treatment by ground crew. Study unable to control for effects of ETI in outcome comparisons.
Adams 1997	Retrospective analysis of prospectively recorded data. 4500 out of hospital (OOH) defibrillated non-traumatic cardiac arrest patients presenting to single EMS; subsequently transported to one of several hospitals. Paramedic ETI versus paramedic or EMT-D BVM. Survival to hospital discharge lower in ETI group for the same number of DC shocks: 1-3 shocks 7.6% vs 19.3 %. 4-6 shocks 7.0% vs 11.0%. > 6 shocks 4.0% vs 10.0%. p <0.002 for all. Outcome differences similar in witnessed/unwitnessed arrest. No adjustment for age, bystander CPR, time to first defibrillation. Success rates and transit times not given.
Atherton 1993	Prospective controlled study comparing of use of combi tube with ETI. Calendar allocation for type of airway used by pre-hospital paramedics for cardiac arrest. No patient outcome data therefore excluded from 52 cases with combi tube (69% success rate) and 81 intubations (84% success). Combi tube also used successfully in 64% ET tube failures. Methodology unclear, data extraction difficult.
Auerbach 1983	43 out of hospital cardiac arrests studied prospectively. No control/comparison group. Entered all patients who had EGTA inserted prehospital and still present at time of arrival in ER. EGTA switched to ETT and gases studied after 5 minutes. Statistically better pO2 and pCO2 with ET tube than with EGTA. EGTA associated with death in ER (p<0.001). Higher proportion of VF in survivors. Down times and ventilation times similar in surviving and dying groups.
Aufderheide 1994	Retrospective observational study with data concerning survival after intubation from near hanging. Intubation performed more frequently in those who died, but severity of trauma not controlled for. No direct comparison possible therefore.
Bochicchio 2003	Prospective study 191 trauma patients with GCS < 9 and head AIS > 2 who survived an initial 48hrs after admission to one trauma centre. Paramedic prehospital rapid sequence ETI versus physician rapid sequence ETI in the ED. Hospital mortality 23% versus 12.4% P=0.05. Incidence of pneumonia 49% versus 22% P=0.02. Groups appear similar in terms of confounders but no adjustment at individual patient level. Field intubation associated with air transport, longer prehospital times and need for urgent neurosurgical intervention. Success rates not given but failures to intubate excluded from study. Ground transit times not given.
Broos 1993	Retrospective review of prospectively recorded data. 121 trauma patients aged >65 yrs admitted to a single centre. Prehospital or emergency department physician ETI (drugs not specified) versus basic manoeuvres. Hospital mortality rate 59% versus 5%. Differences in presenting GCS not adjusted for. No difference in ISS, age and comorbidity in two groups. No adjustment for gender and time to airway intervention. Success rates and transportation times not given.
Buchmann 1992	Retrospective analysis of prospectively recorded data 561 trauma patients GCS <9 at scene and/or requiring neurosurgical intervention. Single trauma centre Physician rapid sequence ETI with drugs at scene versus on arrival in first hospital versus after transfer from first hospital to trauma centre Hospital mortality rates 27% versus 24% versus 24% (not significant) Median age and presenting GCS varied between groups (not adjusted for). No adjustment for injury severity scores or times to scene airway intervention, co-morbidity or gender. Success rates not reported. Ground transit times < 30 minutes.
Bur 2001	Retrospective analysis of prospectively recorded data 276 OOH defibrillated non-traumatic cardiac arrests with ROSC. Single EMS and hospital centre. Physician ETI versus Physician BVM. Good Cerebral Performance Scores Category (1-2) at 6 months equally likely in both groups predictor. OR 0.51-2.31. Adjustment for age, presenting rhythm, bystander CPR, time to first defibrillation. No adjustment for number of shocks. ETI success rates not given. Transit times appear to range from 13 to 204 minutes.
Calkins 1999	Not published when original search performed. Prospective randomised crossover study. Excluded because no patient outcome data. Small numbers (12 paramedics) and flawed (previous experience with ETT).

	Compared ETT, LMA and combitube. 36 manikin insertions under combat conditions. Significantly ($p<0.05$) shorter time for LMA placement than combi-tube, but operator preference was for ETT and combi-tube.
Callaham 1996	Prospective observational study 544 OOH non-traumatic cardiac arrest patients. Single EMS and hospital centre. Paramedic ETI versus paramedic or EMT-D BVM. Good Cerebral Performance Category scores at 6 and 12 months. Equally likely in both groups. OR 02-10. 90% of patients intubated. Up to 10% of cases may have had missing data on key variables in adjustments for confounders. Presenting rhythm and time to defibrillation adjusted for. No adjustment for age, bystander CPR, or number of shocks in VF patients. ETI success rates not given. Urban EMS, transit times < 10 minutes.
Danzl 1989	Retrospective analysis of prospectively recorded data. 428 hypothermic patients (<35C) presenting to US hospitals 95% age >12 yrs. Paramedic ETI or physician ED ETI (? drugs) versus BVM. Likelihood of hospital mortality 3 x higher in ETI group after adjustment for other confounders. No adjustment for presenting Glasgow Coma Score or time to first airway intervention. Success rates and transit times not given.
Davis 2003	Prospective observational study 836 trauma patients with head, or neck AIS > 1, and GCS < 9, and transport time > 10 minutes to one of 5 trauma centres Paramedic prehospital rapid sequence ETI on 209 patients consecutively matched to BVM historical controls for age, gender, AIS score in body regions and receiving trauma centre. Adjusted odds of hospital mortality 1.6 times greater in ETI group $p = 0.03$. 41 retrospective exclusions for non-trauma diagnosis/low severity of injury (7 deaths in first 30 minutes) and protocol violations (250 initial number therefore then became - 209). Unspecified number intubated by aero-medical crew (physician or nurse) but crude outcome still worse in ETI group OR 1.6 when aero-medicals excluded. Paramedics attempted intubation first without drugs. Initial success rate 87% after 3 attempts rest intubated with combitube in ETI group. Morphine and midazolam given post RSI to reduce SBP. Not clear if/when most of control group were intubated in hospital. GCS not controlled for but where data available, head injury diagnoses similar. Data suggest that hyperventilation pCO_2 < 33mm Hg worsens outcome.
Don Michael 1985	Meta-analysis of 4 studies comparing EGTA to ETI in/out of hospital cardiac arrest. Only outcomes were blood gas analysis therefore no survival data.
Durham 1992	Retrospective review of prospectively collected data 389 patients undergoing emergency department thoracotomy at single trauma centre. Paramedic pre-hospital ETI versus BVM then ED physician ETI. Drugs not discussed. Hospital survival 25% versus 10% ($p=0.06$) stab wounds. 11% versus 4% GSW ($p=0.09$) 0% all blunt trauma. No adjustment for age, co-morbidity, ISS, gender, on scene physiology, time to pre-hospital airway intervention. >75% penetrating trauma. ETI success rates not given or transit times. ETI associated with longer pre-hospital/CPR times in survivors.
Eckstein 2000	Retrospective analysis of prospectively recorded data 496 trauma patients requiring at scene airway intervention: subsequently transported to single centre. Paramedic ETI (no drugs) at scene versus paramedic BVM followed by physician ED/immediate operating room rapid sequence ETI. Odds of hospital death 5.3 times greater in paramedic ETI group after adjustment for age, gender, injury severity score and mechanism of injury. Age of two groups similar 54% injured by penetrating trauma. No adjustment for on scene physiology, co-morbidity and time form injury to airway intervention. Scene times similar in both groups. Success rates apparently >99%. Urban ground transport times~10 minutes.
Fortune 1997	Retrospective cohort analysis examining success of emergency cricothyroidotomy in facial injuries or with failed intubation. EMT performed 376 airway manoeuvres in 15,686 patients over 5 years. 56 received cricothyroidotomy. No comparative data, but using TRISS, 5 unexpected survivors and 6 unexpected deaths.
Frankel 1997	Retrospective review of prospectively recorded data 134 trauma registry patients admitted to one trauma centre requiring field or early ED intubation. Paramedic ETI (no drugs) versus BVM then ED physician rapid sequence ETI. Observed - expected mortality rate + 8% versus -14% adjusted for age, mechanism of injury, presenting physiology and injury severity score using US-MTOS coefficients. No adjustment for gender, co-morbidity and times to airway intervention. 81% paramedic versus 99% ED success rate. Adjustments based on US-MTOS rather than sample based coefficients. Urban ground transport for all patients specific times not given.
Garner 1999	Retrospective analysis of prospectively recorded data 296 trauma patients with blunt injury from RTA and initial GCS < 9 who 'survived initial resuscitation' and were transported to either of two trauma centres. Physician

	prehospital rapid sequence ETI (n = 46) or paramedic ETI with no drugs (n = 89) versus BVM (n = 161) then ED physician rapid sequence ETI. Odds of good outcome (GOS) at last contact no different in ETI and BVM groups p = 0.84 adjusted for age, RTS, ISS, subdural haematoma and treatment by physician. 25% patients studied had no outcome data for analysis. Follow-up times differed between ETI and BVM patients. Intubation by physician significantly associated with improved outcome after adjustments OR 2.7 (1.48 - 4.95) versus all paramedic group. All non-intubated prehospital patients subsequently intubated in the ED. Treatment by physician associated with helicopter transport and longer prehospital times. Success rates or average ground transit times not reported.
Garner 2001	Similar observational study of trauma patients to Garner study that has already been included. Compared outcomes between helicoptered trauma patients flown by physicians versus paramedics to one of two trauma centres. Not possible from this data to determine effect of ETI on outcome.
Geehr 1985	Prospective observational study 190 OOH non-traumatic cardiac arrest patients. Single EMS and hospital centre. Paramedic ETI versus paramedic EGTA Survival to hospital discharge 4.0% versus 4.3% (NS) 20 (11%) no data on airway intervention. Groups similar in terms of presenting rhythm and time to defibrillation in VF. EGTA group significantly younger. No data on bystander CPR and number of shocks for VF patients. ETI success rate 91%. Urban system transit times < 20 minutes.
Gordon 1995	Study of 2298 head injury patients over 20 years. Did not directly correlate airway management with outcome.
Hammargren 1985	Crossover study comparing blood gas results of EGTA with ETT. No patient outcome data. 91 non-traumatic cardiac arrests, all with EGTA initially. 48 were changed to ETT and blood gases in both groups compared. Satisfactory ventilation with EGTA.
Hedges 2002	Retrospective analysis of prospectively recorded data 501 trauma registry patients presenting with GCS <9 to 21 'level 3' trauma centres. Physician rapid sequence ETI in ED versus physician BVM. Significance of ((observed - expected)/S error) mortality rate: -4.2 in both groups. Adjusted for age, mechanism of injury, presenting physiology by MTOS US coefficients. Gender similar in both groups. No adjustment for gender co-morbidity and time to airway intervention. Adjustments on MTOS rather than sample data predictions. Success rates and transit times not given.
Hillis 1993	Prospective observational study. 191 OOH non-traumatic cardiac arrest patients. 3 EMS systems single hospital centre. Paramedic ETI versus paramedic EOA versus paramedic or EMT-D BVM. Survival to hospital discharge 12.5% versus 4.5% versus 3.9% (ns). Significant improvement for ETI if EOA and BVM grouped together in comparison P<0.05. Age of groups appears similar. Bystander CPR less likely in non ETI group (27 versus 35%). Also incomplete adjustment for other important confounders: Presenting rhythm, time to defibrillation and number of shocks in VF. Further group of 60 patients offered by authors as control not considered for review as no data on presenting rhythm. Transit times < 15 minutes. ETI success rates not given.
Holmberg 2002	Retrospective analysis of prospectively recorded data 10,966 OOH non-traumatic cardiac arrest patients. Multiple EMS and hospitals. Paramedic ETI versus paramedic or EMT-D BVM. Prediction of one-month survival. ETI independent predictor of poor outcome. OR 0.51-0.99. In multiple logistic regression result up to 40% of cases were excluded due to missing data. Effect of ETI disappeared if response times/times to defibrillation accounted for. Otherwise full adjustment for all known confounders. ETI success rates not given. Transit times ~10 minutes.
Huf 1996	Retrospective analysis of prospectively recorded data 377 multiply injured patients with lung contusion, single trauma centre. Pre hospital physician rapid sequence ETI versus ED physician rapid sequence ETI. Hospital mortality 22.1% versus 23.7% non-significant. Age and injury severity similar between groups. No adjustment for presenting physiology, gender and comorbidity. No adjustment for times to airway intervention. Non-significant reduction in ARDS + pneumonia rate in pre-hospital ETI group which had significantly shorter ICU times. Success rates and transit times not given.
Karch 1996	Retrospective cohort of 94 trauma patients requiring field intubation. Intubation success rate not statistically different in survivors and non-survivors but groups not comparable. Non-survivors had worse TS/ISS and GCS. Blood pressure was a strong predictor of survival.

King 1994	Prospective observational study 137 physician attended in hospital non traumatic cardiac arrests. Single centre Physician ETI versus physician/nurse BVM. Six month survival 12.7% versus 36.7% (P<0.005). No adjustment for any confounder.
Kuchinski 1991	Retrospective review of prospectively recorded data 41 trauma registry patients admitted to single centre ISS<16. Physician rapid sequence ETI for agitation versus observation of non agitated patients. Hospital mortality 5% versus 0%. Mean cost per hospital stay $7150 versus $3456 p<0.05. Differences in age, physiology and ISS between groups not adjusted for. No adjustment for gender, or co-morbidity. ETI success rate 95%. Death resulting from unrecognised oesophageal intubation. Transit times not specified.
Liberman 2000	Meta analysis of studies comparing prehospital ALS and BLS for trauma patients. Not possible to separate out the effect of ETI from ALS.
Marwick 1991	Prospective observational study 710 physician attended in hospital non traumatic cardiac arrests. Single centre. Physician ETI versus physician/nurse BVM. Survival to hospital discharge significantly less likely in intubated group. OR 0.2 - 0.9. Adjusted for all confounders except number of shocks in VF patients.
Murray 2000	Retrospective analysis of prospectively recorded data 894 trauma patients with GCS < 9 and head AIS > 3 received by 13 trauma centres. Paramedic prehospital ETI (no drugs) versus paramedic prehospital attempted (failed) ETI versus paramedic prehospital BVM Relative risk of hospital mortality 1.74 (1.41- 2.00) times higher ETI versus BVM 1.53 (1.15 - 1.85) failed ETI versus BVM. Adjusted for gender, GCS, head AIS score, ISS, transport mode (ground air), mechanism of injury and associated injury. 57/178 (>33%) failure rate after 3 attempts for ETI with no drugs. Only 754 included in relative risk analysis (missing data). Results similar in matched patients sub-sample (for age also). Not clear if failed ETI or BVM patients later intubated in trauma centre. Apparent inadequate respiratory effort was indication for intubation. All ground transportation times not specified
Norwood 1994	Retrospective cohort analysis of emergency room intubations over a 4-year period. Excluded because no comparison with any other airway device. 229 patients with mean ISS 29 and mean RTS 9, intubated in emergency room. Concluded intubation is safe in ER if performed by experienced personnel using drugs. 6 cricothyroidotomies for failed intubation (2 died of severe head injuries GCS 3) and 8 cervical spine injuries with no cord damage. 1 possible aspiration during intubation left hospital alive.
Orliaguet 1997	Prospective observational study of 153 patients with in-field intubation performed by physicians. No treatment comparison, and only outcome measure studied was pulmonary aspiration. Concludes prehospital intubation by physicians has a low risk of complications (compared to paramedic studies).
Oswalt 1992	Retrospective analysis of prospectively recorded data 82 trauma registry patients to one trauma centre. Paramedic ETI (no drugs) versus physician rapid sequence ETI with drugs in ED <10 mins, 10 mins - 2 hrs, >2hrs after arrival. Significance of ((observed - expected)/standard error) mortality rate. Only significantly (negative) in > 2 hrs group. Adjusted for age, mechanism of injury and presenting physiology by MTOS US coefficients. No adjustment for gender, co-morbidity or time to airway intervention. Adjustments made from US MTOS coefficients. ED deaths/cricothyroidotomies excluded. No failed intubations. Transit times not given.
Pointer 1988	Retrospective analysis of prospectively recorded data 383 OOH non-traumatic cardiac arrest patients. Single EMS and hospital paramedic ETI versus paramedic BVM. Survival to hospital admission 23% versus 8%. 93% of patients intubated, = 7% failure after 3 attempts. Significant complication rate. No adjustment for any confounder. Transit times not given.
Rainer 1997	Prospective observational study 240 non-traumatic OOH cardiac arrest patients. Single EMS and hospital centre. Paramedic ETI versus paramedic EMT-D BVM. Survival to hospital admission 15% versus 23% (ns). Intubation data missing on 10% of cases. Inadequate adjustment for presenting rhythm, bystander CPR, age and time to first defibrillation. No adjustment for number of shocks and witnessed arrest. ETI success rate not given. Transit times <10 minutes.
Regel 1997	Retrospective analysis of prospectively recorded data. 1223 trauma registry patients with ISS>20. Physician prehospital intubation versus basic manoeuvres. No mortality rates given only multiorgan failure rates.

Rhee 1994	Randomised controlled trial comparing nasal intubation with oral intubation and neuromuscular blockade in adult trauma patients. Helicopter crew consisted of nurses. Excluded because heavily flawed. Low power, outcome data analysis unclear, no intention to teat analysis. Crew allowed to attempt oral intubation or cricothyroidotomy before randomisation, and also to cross over the assigned technique based on their clinical beliefs about the patient. 174 patients entered but many excluded from data so data from only 77 analysed. 44 nasal and 33 NMB. Intubation times for both procedures were very long (2.9 mins nasal, 5.9 mins oral) although similar success rates (79.5% nasal, 75.8% oral).
Ruchholtz 2002	Retrospective analysis of prospectively recorded data 44 pairs of severe thoracic trauma GCS >7 patients matched for age, gender, survival probability and mechanism (blunt/penetrating) according to intubation status. 33 participating hospitals. Intubation by physicians in the prehospital environment (EI versus later physician intubation in ED or ICU) (DI) (drugs not specified). In hospital mortality 13.6% versus 4.5% (non-significant). Low power. Multiple exclusions 457 initially eligible patients to 44 matched pairs (for missing data, interhospital transfer, and death within 24 hours). EI patients longer scene times, more frequent helicopter transport, more on scene fluid. Multiple different hospitals. Success rate not reported. 2 DI never intubated. Transit times 8-20 minutes 50% in helicopter.
Rumball 1997	Modified randomised crossover comparison of PTL, LM and Combitube with BVN used by medical assistants pre-hospital. Assessed for control of ventilatory parameters by blood gases and spirometry. 470 patients in cardiac arrest: 142 PTL, 147 LM, 90 Combitube, 91 BVM. Unclear if groups similar with respect to initial rhythm, although response times similar. No significant difference in insertion rates and ventilation between devices, although subjective evaluation of BVM was worst overall. Insertion rates 80% for modified tubes i.e. 1 in 5 failure risk when used prehospital.
Sanson 1999	244 entrapped trauma patients managed by a Regional Helicopter Emergency Medical Service. Not possible to directly correlate intubation status to outcome.
Schmidt 1992	Retrospective review of prospectively recorded data. 407 trauma patients transferred by helicopter in US and Germany. Unable to correlate airway management status with outcome.
Schneider 1995	Prospective study using historical controls. No comparison of airway devices. Physician led resuscitation of pre-hospital cardiac arrests. Examined impact of standardised training. 145 total cases, 64 before training, and 81 after. No significant differences in survival or discharge from hospital. Significant differences in the impact of training were earlier intubation and greater use of ET adrenaline in PEA/asystole.
Shea 1985	Prospective observational study 374 OOH defibrillated non-traumatic cardiac arrest patients. Single EMS and hospital centre. Paramedic ETI versus paramedic EGTA. If ETI failed twice switched to EGTA. Long term survival (time period not specified) 11.5% versus 16.2% (ns). 78 (21%) of cases excluded from analysis due to protocol violations, missing data or non cardiac cause of arrest. Groups similar in terms of age and response times. Bystander CPR and witnessed arrest more likely in EGTA group. No adjustment for number of shocks. Success rates 93.4 versus 95%. Transit times less than 5 minutes.
Sloane 2000	Retrospective analysis of prospectively recorded data 75 patients with GCS <9 and Head AIS >2 (no other serious injury) same trauma centre. Physician/nurse prehospital ETI (rapid sequence) prior to helicopter transit versus BVM then ED physician ETI (rapid sequence) 30 day mortality 14% versus 22% ($p = 0.54$). Time period of study longer (88 - 95) for prehospital group (versus 93 - 94). 10% ED cases may not have been eligible for inclusion due to missing data. Further 50% ED cases and unspecified number prehospital cases not eligible due to non-rapid sequence ETI method. Low power study. Pre-hospital ETI significantly younger ($p<0.01$) - not adjusted for; otherwise groups appear similar in terms of confounders. Success rates 98% in both groups after 3 attempts. Higher rates of pneumonia in field ETI group. Ground transit time for ED cases 13.3 minutes.
Staudinger 1994	86 out of hospital cardiac arrest patients. Prospective study, one at centre. Paramedics ETI versus Combi. Results not analysed on intention to treat or actual airway received basis but on groups where airway was attempted. Results cross as 22 patients have attempts at both.

Characteristics of excluded studies (*Continued*)

	No adjustment for any confounder. Success rates 71% for each (poor).
Stratton 1998	Observational study of survival in 1974/75 versus 1995 in/out of hospital cardiac arrest. Not possible to correlate ETI status and outcome.
Tanigawa 1998	Retrospective review of use of airway devices in 12,020 cases of non-traumatic cardiac arrest. No prognosis data but compared successful use of LM, Combitube and EGTA in Japanese EMTs. Combitube most appropriate choice for successful insertion and ventilation, but greater incidence of soft tissue injuries.
Trupka 1995	Prospective observational study 131 trauma patients aged 16-70 with ISS >18 within 6 hours of injury at single trauma centre. Early physician rapid response ETI (<2 hours after injury) or later physicians rapid sequence ETI. Hospital mortality (15% versus 26% and multi organ failure) (28% versus 37%) both ns. No difference in age or gender between groups. ISS higher P< 0.001 and presenting blood pressure lower in early intubation group. No adjustment for presenting GCS, gender, co-morbidity or time to pre-hospital airway intervention. ETI success rates and transit times not reported. 6 patients not intubated at all (100% survival). 21% of sample who died in first 24 hours excluded.
Wald 1993	Study of 170 patients with head injury comparing outcomes in those with/without hypoxia and/or hypotension. Unable to correlate airway management with outcome from this data.
Westhoff 2002	Prospective observational study 48 patients with thoracic trauma at 22 centres. Pre-hospital physician rapid sequence ETI versus BVM then ED physician rapid sequence ETI. Hospital mortality 8% versus 36%. Multi organ failure 42% versus 80%. Emergency department groups 10 years older on average. ISS scores similar. No adjustment for presenting physiology, co-morbidity, gender and times to scene airway intervention. Success rates not given. Mainly helicopter transport.
Winchell 1997	Retrospective analysis of prospectively recorded data a) 1092 blunt trauma patients with GCS<9 admitted to one of six trauma centres, ground transfers b) 502 blunt trauma patients GCS<9 air transport to one of six trauma centres a) Paramedic pre-hospital ETI (no drugs) versus BVM b) Paramedic or nurse pre-hospital rapid sequence ETI versus BVM Hospital mortality a) 26% versus 36% p<0.05 b) 35% versus 21% p<0.05. a) Biggest mortality difference if GCS>3 isolated closed head injury 8.6 versus 22%. Groups similar in terms of age, ISS, presenting GCS. No adjustment for gender, co-morbidity, times to airway intervention. b) Nonsignificant difference in severe closed head injury. No adjustment for all other confounders. ETI success rates 99% in b) not specified in a Transit time not specified. Later intubation rates in trauma centre not specified.
Xeropotamos 1993	Retrospective, descriptive data examining the efficacy of advanced airway techniques in 143 cases (out of 600 seen) over a 12-month period. Inherently biased because didn't compare ET intubation with cricothyroidotomy in all cases. Looked only at cases where ET intubation not possible or failed, 11 in total, of whom 4 survived. Concluded surgical airway can be a lifesaving procedure if performed rapidly.

ADDITIONAL TABLES

Table 01. Search strategies

CENTRAL issue 4, 2006
#1MeSH descriptor Intubation explode all trees
#2(intubate* or intubation):ti or (intubate* or intubation):ab
#3(#1 OR #2)
#4MeSH descriptor Heart Arrest explode all trees
#5MeSH descriptor Myocardial Infarction explode all trees
#6MeSH descriptor Resuscitation explode all trees
#7(sudden cardiac death):ti or (sudden cardiac death):ab
#8heart near (injur$ or rupture$ or massage) #9cardiac near massage
#10cardiopulmonary resuscitation
#11advanced cardiac life support
#12((myocardial) near (infarc* or hibernation or contraction or reperfusion or reperfusion injury)):ti or ((myocardial) near (infarc* or hibernation or contraction or reperfusion or reperfusion injury)):ab
#13myocard* near stun*
#14cardiogenic near shock*
#15artificial respiration
#16(#4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15)
#17(#3 AND #16)
#18MeSH descriptor Time Factors explode all trees
#19(acute or emergency or emergencies or pre hospital or early intervention or delayed intervention or EI or DI or timing or scene):ti or (acute or emergency or emergencies or pre hospital or early intervention or delayed intervention or EI or DI or timing or scene):ab
#20MeSH descriptor Emergencies explode all trees
#21(#18 OR #19 OR #20)
#22(#17 AND #21)

MEDLINE 1950 to 2006 Nov (week 3)
1.exp Intubation/
2.(intubate$ or intubation).ab,ti.
3.exp Heart Arrest/
4.exp Myocardial Infarction/
5.exp Resuscitation/
6.(sudden adj3 cardiac adj3 death).ab,ti.
7.(heart adj3 (injur$ or rupture$ or massage)).ab,ti.
8.(cardiac adj1 massag$).ab,ti.
9.“cardiopulmonary resuscitation”.ab,ti.
10.“advanced cardiac life support”.ab,ti.

Table 01. Search strategies (*Continued*)

11.(myocardial adj3 (infarc$ or hibernation or contraction or reperfusion or "reperfusion injury")).ab,ti.
12.(myocard$ adj1 stun$).ab,ti.
13.(cardiogenic adj3 shock$).ab,ti.
14."artificial respiration".ab,ti.
15.1 or 2
16.or/3-15
17.15 and 16
18.exp time factors/
19.(acute or emergency or emergencies or pre?hospital or "early intervention" or "delayed intervention" or "EI" or "DI" or timing or scene).ab,ti.
20.exp Emergencies/
21.or/18-20
22.17 and 21
23.Randomized controlled trial.pt.
24.(random or randomly or randomised or randomized).ab,ti.
25.23 or 24
26.exp Animals/
27.exp Humans/
28.26 not (26 and 27)
29.25 not 28
30.22 and 29

EMBASE 1980 to week 50, Dec 2006
1.exp intubation/
2.(intubate$ or intubation).ab,ti.
3.exp Heart Arrest/
4.exp Heart Infarction/
5.exp resuscitation/
6.(sudden adj3 cardiac adj3 death).ab,ti.
7.(heart adj3 (injur$ or rupture$ or massage)).ab,ti.
8.cardiac massag$.ab,ti.
9.cardiopulmonary resuscitation.ab,ti.
10.advanced cardiac life support.ab,ti.
11.(myocardial adj3 (infarc$ or hibernation or contraction or reperfusion or "reperfusion injury")).ab,ti.
12.(myocard$ adj1 stun$).ab,ti.
13.(cardiogenic adj3 shock$).ab,ti.
14.artificial respiration.ab,ti.
15.1 or 2
16.or/3-14

Table 01. Search strategies (*Continued*)

17.15 and 16
18.exp time/
19.(acute or emergency or emergencies or pre hospital or early intervention or delayed intervention or EI or DI or timing or scene).ab,ti.
20.exp emergency/
21.or/18-20
22.17 and 21
23.placebo.ti,ab.
24.groups.ti,ab.
25.exp randomized controlled trial/
26.(random or randomly or randomised or randomized).ti,ab.
27.exp animals/
28.exp humans/
29.27 not (27 and 28)
30.23 or 24 or 25 or 26
31.30 not 29
32.22 and 31

National Research Register Issue 4, 2006
1.INTUBATION explode tree 1 (MeSH)
2.(intubate* or intubation)
3.(#1 or #2)
4.EMERGENCIES explode all trees (MeSH)
5.TIME FACTORS explode all trees (MeSH)
6.(emergency or emergencies)
7.(acute or emergency or emergencies or (pre next hospital) or (early next intervention) or (delayed next intervention) or ei or di or timing or scene)
8.(#4 or #5 or #6 or #7)
9.(#3 and #8)

GRAPHS AND OTHER TABLES

This review has no analyses.

COVER SHEET

Title	Emergency intubation for acutely ill and injured patients
Authors	Lecky F, Bryden D, Little R, Tong N, Moulton C
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Date new studies sought but none found	Information not supplied by author
Date new studies found but not yet included/excluded	Information not supplied by author
Date new studies found and included/excluded	Information not supplied by author
Date authors' conclusions section amended	Information not supplied by author
Contact address	Dr Fiona Lecky Research Director, Trauma Audit and Research Network (TARN) Department of Emergency Medicine Hope Hospital Clinical Sciences Building Eccles Old Road Salford M6 8HD UK E-mail: fiona.lecky@manchester.ac.uk Tel: +44 (0)161 206 4397 Fax: +44 (0)161 206 4345
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