Advanced airway management is necessary in prehospital trauma patients

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Background. Treatment of airway compromise in trauma patients is a priority. Basic airway management is provided by all emergency personnel, but the requirement for on-scene advanced airway management is controversial. We attempted to establish the demand for on-scene advanced airway interventions. Trauma patients managed with standard UK paramedic airway interventions were assessed to determine whether airway compromise had been effectively treated or whether more advanced airway management was required.

Methods. A prospective observational study was conducted to identify trauma patients requiring prehospital advanced airway management attended by a doctor–paramedic team. The team assessed and documented airway compromise on arrival, interventions performed before and after their arrival, and their impact on airway compromise.

Results. Four hundred and seventy-two patients required advanced airway intervention and received 925 airway interventions by ground-based paramedics. Two hundred and sixty-nine patients (57%) still had airway compromise on arrival of the enhanced care team; no oxygen had been administered to 52 patients (11%). There were 45 attempted intubations by ground paramedics with a 64% success rate and 11% unrecognized oesophageal intubation rate. Doctor–paramedic teams delivering prehospital anaesthesia achieved definitive airway management for all patients.

Conclusions. A significant proportion of severely injured trauma patients required advanced airway interventions to effectively treat airway compromise. Standard ambulance service interventions were only effective for a proportion of patients, but might not have always been applied appropriately. Complications of advanced airway management occurred in both provider groups, but failed intubation and unrecognized oesophageal intubation were a particular problem in the paramedic intubation group.

Keywords: airway management; intubation; prehospital emergency care

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Timely and appropriate airway management is essential for severely injured trauma patients since airway compromise is considered to be a significant cause of poor outcome and preventable death in this patient population.1,2 This study was performed to establish the frequency of airway compromise in trauma patients in the period shortly after injury. Early advanced airway interventions can be provided by enhanced care personnel. For example, prehospital doctor–paramedic teams are capable of all advanced airway interventions (including prehospital anaesthesia and surgical airway), but these are costly and relatively scarce resources. It is important to understand whether there is demand for these skills in addition to those routinely provided by ambulance service personnel. Although there is a perception that advanced airway management is required for severely injured trauma patients on scene, there are no recently published quantitative data on the demand. To address this question, we attempted to establish whether available standard UK paramedic airway interventions dealt adequately with identified airway compromise in trauma patients, or if further advanced airway management was required.

Methods

A prospective observational study was conducted over a 1 yr period (April 2012–March 2013) to identify all prehospital trauma patients attended by an enhanced care doctor–
paramedic team who required an airway intervention on scene in London, UK. An airway intervention was defined as oral or nasal airway insertion, supraglottic airway insertion, tracheal intubation, or assisted ventilation. In addition to standard clinical data collection, the doctor–paramedic team was asked to agree and record any airway compromise at the point of their arrival on scene and any interventions that had been carried out by ambulance service personnel to manage the airway before the enhanced care team arrival. This was an attempt to determine whether any remaining compromise was due to the interventions being ineffective or because (for whatever reason) appropriate interventions had not been attempted. The type, success, and resulting complications of interventions carried out subsequently were also recorded. The local ambulance service, which attended the majority of patients in the study, has stopped training paramedics in the skill of intubation without drugs. However, those paramedics who registered before June 1, 2010, retain this skill. During the study period, both standard laryngeal mask airways™ and the I-Gel™ airway were used as supraglottic airway devices by ambulance service paramedics.

The attending enhanced care team consisted of a doctor and a paramedic. The doctors have a minimum of 5 yr postgraduate experience and are usually from the specialties of anaesthesia or emergency medicine with competency in the full range of advanced airway management skills, including prehospital anaesthesia. The enhanced care team paramedic is an experienced paramedic seconded from the local ambulance service with specific selection and training for an extended role. The enhanced care team is delivered to the scene by helicopter or fast response cars.

Dispatch of the enhanced care team is via a flight paramedic who screens calls to the ambulance control room. Three categories of dispatch were used in the study period. ‘Immediate’ dispatch on the basis of the caller indicating one of the following trauma mechanisms: person under a train, road traffic collision with person trapped, associated fatality, or person ejected, fall of more than two storeys, and traumatic amputation above the wrist or ankle. The second category is ‘interrogation’. An ambulance is dispatched and the flight paramedic speaks to the call maker to try and establish the facts of the incident and state of the patient. If serious injury is suspected, the enhanced care team is dispatched. The third category of dispatch is ‘crew request’ where an ambulance crew can request the attendance of the enhanced care team after assessment of the patient. The project proposal was viewed by the local research and development department (London’s Air Ambulance). The project met the criteria for, and was registered as, a service evaluation project. No additional interventions were carried out and the study recorded only the frequency of events in normal practice with a view to service improvement. Ethical approval was therefore not required.

Results
In total, the doctor–paramedic team attended 1963 patients during the 1 yr study period (April 1, 2012–March 31, 2013); 472 patients (24.0%) required advanced airway management and were intubated on scene. Of these patients, 368 were males (78%) and 104 were females (22%); the mean age was 40 yr (range 0–95). The most common mechanisms of injury were road traffic collision, 187 patients (39.6%); falls, 137 patients (29%); assaults, 50 patients (10.6%). Ninety-four patients died on scene (19.9%). On arrival of the doctor–paramedic team, 469 patients had ambulance service personnel in attendance. On three occasions, the doctor–paramedic team arrived on scene first. Of the 469 patients where ambulance service personnel were first on scene, 269 (57%) had airway compromise on arrival of the enhanced care team. Complete airway obstruction was present in 16 patients and partial airway obstruction in 158 patients. Paramedics initially reported two recognized oesophageal intubations. Gross airway contamination was reported in 159 patients: 104 were contaminated with blood, 39 with vomit, and 16 with both. Some patients were reported to have more than one type of airway compromise (Fig. 1).

Ambulance service airway management
Overall, 925 airway interventions had been performed on 469 patients by the ambulance service before arrival of the doctor–paramedic team (Table 1). Of the 200 patients without airway compromise on arrival of the enhanced care team, 134 (67%) had received ambulance service airway interventions. Fifty-two patients (11%) did not have oxygen applied at the point of arrival of the enhanced care team. In 159 patients, the airway was grossly contaminated with blood or vomit. Suctioning of the airway to remove the contamination was reported to have been carried out in 56 patients (39%). The frequency of airway interventions was examined in these two groups in more detail (Table 2).

Ninety-four patients underwent advanced airway interventions by ambulance service paramedics before enhanced care team arrival (tracheal intubation without drugs or supraglottic airway insertion). There were 45 attempted intubations. Twenty-nine intubation attempts (64%) were successful; of which, 27 (93%) were in patients in established cardiac arrest. Sixteen attempted intubations (36%) were unsuccessful. There were five unrecognized oesophageal intubations identified after enhanced care team attendance, and two oesophageal intubations that had been recognized but not rectified until after enhanced care team attendance. Forty-eight out of 52 supraglottic airway insertions (92%) were successful.

Doctor–paramedic airway management
Thirty-nine doctors attended the patients in this study period. Non-anaesthetists managed 247 patients (52.3%), and anaesthetists managed 225 (47.7%) patients. Fifty-eight per cent of cases were attended by fast response car and 42% by helicopter. The median time to arrival on scene by helicopter after activation was 16 (range 4–32) min. The median time to arrival on scene by fast response car after activation was 19 (range 2–49) min.

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All patients transported to hospital had successful prehospital intubation by the enhanced care team. The recorded indications for prehospital intubation or anaesthesia and intubation are recorded in Table 3. The group of patients who received no ambulance service airway interventions and did not have airway compromise on doctor–paramedic arrival (66 patients) were all in the ‘combative or uncooperative’ or ‘relief of pain or distress’ categories.

The choice of anaesthetic agents is dictated by service standard operating procedures. The majority of patients had a standard rapid sequence induction with an induction agent (ketamine), an opioid (fentanyl), and a neuromuscular blocking agent (NMBA) (rocuronium). Haemodynamically unstable patients might have had the opioid omitted and patients in cardiac arrest were usually intubated without the use of drugs. The use of drugs in this study population is shown in Table 4.
Recorded complications of advanced airway management by the enhanced care team included four tracheal tubes immediately recognized as misplaced in the oesophagus. All were corrected before finishing laryngoscopy. Three right mainstem bronchus intubations were also identified and corrected before leaving scene. In addition, there were 13 reports of vomiting or aspiration before or during intubation, 19 reports of hypoxia ($\text{SpO}_2 < 90\%$), one episode of bradycardia (heart rate < 50 beats min$^{-1}$), and 15 reports of hypotension after induction (systolic arterial pressure < 90 mm Hg; Table 5).

### Discussion

The results of this prospective observational study demonstrate that airway compromise is frequent in patients attended by this physician-led prehospital trauma service. The study included mostly blunt trauma in young male patients. The high rate of cardiac arrest and death on scene (19.9%) also confirm the high severity of injury in the study population. This finding is in keeping with other studies that have recorded airway compromise in trauma patients in the prehospital phase of care$^3$ or on arrival at the emergency department.$^4$ UK data are scarce, but the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) report ‘Trauma Who Cares’ published in 2007 reported that 12.6% of major trauma patients arrived in the emergency department with a partially or completely obstructed airway and had a higher mortality.$^5$ Although the reported rate of airway compromise is high in the trauma patients in this study, the number of trauma patients is very small in the context of the huge number of calls to the ambulance service in the same period. (The approximate number of calls to the local ambulance service in study period was 1,605,956, www.londonambulance.nhs.uk, accessed November 2013).

<table>
<thead>
<tr>
<th>Complication</th>
<th>Number of patients</th>
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<tr>
<td>Recognized oesophageal intubation</td>
<td>4</td>
</tr>
<tr>
<td>Recognized mainstem bronchus intubation</td>
<td>3</td>
</tr>
<tr>
<td>Unrecognized oesophageal intubation</td>
<td>0</td>
</tr>
<tr>
<td>Trauma to teeth</td>
<td>0</td>
</tr>
<tr>
<td>Vomiting, aspiration, or both</td>
<td>13</td>
</tr>
<tr>
<td>Hypoxia</td>
<td>19</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>1</td>
</tr>
<tr>
<td>Hypotension</td>
<td>15</td>
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There is little written about the nature of airway contamination in trauma patients, but the findings of this study that gross airway contamination is mostly from blood (from above) rather than vomit (from below) are in keeping with previous studies from our system.$^6$ If these findings are a true reflection of this patient group, they suggest that supraglottic airways could provide a degree of protection against aspiration by providing a degree of protection from upper airway soiling.

This study suggests that standard ambulance service interventions were only effective for a proportion of patients. This could be because the interventions available are not always effective for this patient group, but this is only true if the available interventions were applied appropriately and consistently.

### Table 5 On-scene complications of advanced airway management carried out by doctor-paramedic team

<table>
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The results suggest that a significant proportion of patients with airway compromise were successfully managed with airway interventions performed before enhanced care team arrival. The data also suggest that airway management was suboptimal in a number of cases. Failure to apply oxygen to major trauma patients in a very short time is a serious omission. This occurred in 11% of patients in this study. In the 2007 NCEPOD report ‘Trauma: Who Cares?’ it was reported that 26.2% of trauma patients did not have oxygen applied by the time of arrival in the emergency department. Although 11% of patients did not have oxygen applied in this study, this represents a significant improvement on the NCEPOD data, particularly as oxygen may well have been applied to a number of patients before leaving scene had the enhanced team not attended.

The degree of compromise was not recorded, but it is likely that a proportion of patients who did not have interventions (with airway obstruction or airway contamination) might have benefited from basic airway manoeuvres or, in the case of gross contamination, attempts at airway suction. The amount of time the ambulance service had on scene to resolve airway problems before arrival of the doctor–physician team has not been recorded. However, more than 75% of high acuity calls were attended by the ambulance service within 8 min (www.londonambulance.nhs.uk).

Ninety-four patients had advanced airway interventions attempted by ambulance service paramedics. These consisted of supraglottic airway insertion and intubation without drugs. The supraglottic airway insertion success rate is high (92%) and in keeping with previously published prehospital success rates. The attempted intubations had a high failure rate (36%) and significant complications. Unrecognized oesophageal rates of more than 10% (even in cardiac arrest) are unacceptable. Although the numbers in this study are small, they provide more evidence that intubation without drugs by paramedics may do more harm than good. There is good evidence that the success rate of tracheal intubation is dependent on the use of sedatives and neuromuscular blockers. All patients were successfully intubated by the attending physicians in this study. Prehospital intubation success rates of more than 99% have consistently been reported for prehospital physicians. Our service has reported 99.3% intubation success rates in more than 7000 intubations.

The successful paramedic intubations without drugs were virtually all in patients in traumatic cardiac arrest, and benefit has been previously seriously questioned in this patient group. The data presented suggest that the move by the ambulance service, that attended the majority of the patients in this study, and by JRCALC to stop training paramedics in intubation without drugs is the correct one. The local ambulance service has also recently commenced work on a project to deliver enhanced training to selected paramedics. This, in combination with careful dispatch, may result in the small group of trauma patients at risk of airway compromise being attended by more experienced practitioners with high-quality airway management skills.

The data presented from this study suggest that current ambulance service provision does not meet the needs of the seriously injured patient with airway compromise. A doctor–paramedic team with rapid sequence induction capability do appear to be able to successfully manage airway compromise, although complications still occur regularly in this high-risk patient group.

**Limitations of this study**

Limitations of this study include the fact that the exact time that the ambulance service had on scene to resolve airway problems before arrival of the doctor–physician team is likely to have been variable. Although the nature of airway compromise is documented, the degree of compromise and the possible consequences of not treating each patient are not clear. The enhanced care team doctor and paramedic were asked to assess and document the nature and effectiveness of airway interventions that had been carried out before arrival of the team. The authors recognize that this approach is open to bias. Agreement between the team members was sought in an effort to reduce observer subjectivity and limit bias. The enhanced care team also commented on their own airway management, which is also subject to potential bias, although the 100% successful intubation rate before leaving scene is not open to interpretation. An attempt was made to assess whether patients with an inadequate airway remained compromised after standard management interventions had been carried out or when (for whatever reason) standard management had not been attempted. It may not always have been possible to establish which interventions had been attempted before arrival of the enhanced care doctor–paramedic trauma team. There may have been bias from under or over self-reporting of complications of advanced airway management of the attending doctor–paramedic team. The authors did not have access to information on trauma patients not attended by the enhanced care team and therefore could not comment on the airway management of patients attended by the ambulance service without the enhanced care team.

**Authors’ contributions**

D.J.L.: conceived and designed the study, collected the data, and co-author of the first and subsequent drafts; B.H.: initial data analysis and author of the first draft; K.C.: co-author of subsequent drafts and reviewed and constructively criticized the manuscript; G.C.: designed and reviewed and constructively criticized the manuscript; A.E.W.: reviewed and constructively criticized the manuscript; G.E.D.: reviewed and constructively criticized the manuscript.

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**Declaration of interest**

None declared.
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