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Clinical Paper

How do paramedics manage the airway during out of hospital cardiac arrest?

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ABSTRACT

Aim: The best method of initial airway management during resuscitation for out of hospital cardiac arrest (OHCA) is unknown. The airway management techniques used currently by UK paramedics during resuscitation for OHCA are not well documented. This study describes the airway management techniques used in the usual practice arm of the REVIVE-Airways feasibility study, and documents the pathway of interventions to secure and sustain ventilation during OHCA.
Method: Data were collected from OHCAs attended by paramedics participating in the REVIVE-Airways trial between March 2012 and February 2013. Patients were included if they were enrolled in the usual practice arm of the study, fulfilled the main study eligibility criteria and did not receive either of the intervention supraglottic airway devices during the resuscitation attempt.
Results: Data from 196 attempted resuscitations were included in the analysis. The initial approach to airway management was bag-mask for 108 (55%), a supraglottic airway device (SAD) for 39 (20%) and tracheal intubation for 49 (25%). Paramedics made further airway interventions in 64% of resuscitations. When intubation was the initial approach, there was no further intervention in 76% of cases; this compares to 16% and 44% with bag-mask and SAD respectively. The most common reason cited by paramedics for changing from bag-mask was to carry out advanced life support, followed by regurgitation and inadequate ventilation. Inadequate ventilation was the commonest reason cited for removing a SAD.
Conclusion: Paramedics use a range of techniques to manage the airway during OHCA, and as the resuscitation evolves. It is therefore desirable to ensure that a range of techniques and equipment, supported by effective training, are available to paramedics who attend OHCA.

1. Introduction

In the United Kingdom (UK) there are 118 out of hospital cardiac arrests (OHCAs) per 100,000 population per annum.[1] The ambulance service attends 60,000 OHCA patients each year,[2] with half of these cases receiving a resuscitation attempt. Unfortunately survival rates remain low, with approximately 7% of OHCA patients in the UK surviving to hospital discharge.[3]

There is an urgent need to investigate interventions which improve outcomes from OHCA. Bystander cardiopulmonary resuscitation (CPR) improves survival rates,[4] and effective ventilation is an essential component of CPR unless the duration of cardiac arrest is very short.[5] Effective ventilation is associated with both return of spontaneous circulation (ROSC) and neurological recovery following cardiac arrest.[6] Pre-hospital clinicians should secure the airway and provide effective ventilation without prolonged interruptions in chest compressions.[7] The pre-hospital environment is challenging: access to the patient may be problematic and the risk of regurgitation and aspiration are high.[8,9] A functioning airway device may also dislodge during patient extrication and transport.

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The best method for managing the airway during OHCA is unknown, although several recent observational studies have provided data. The practice of tracheal intubation by paramedics has been questioned because of the risk of unrecognised oesophageal intubation and prolonged interruptions in chest compressions.[10] UK ambulance services have been encouraged to consider the use of newer supraglottic airway devices.[11] Supraglottic airway devices are now used routinely in many UK ambulance services,[12] with some services also phasing out intubation training for new paramedics. In 2011/12 London Ambulance Service reported 1,439 successful OHCA intubations and 1,570 successful SAD placements.[13]

A secondary analysis of data from North America showed that tracheal intubation was associated with better outcomes than the use of SADs.[14] In contrast, data from a Japanese registry of OHCA suggests that bag-mask ventilation is associated with improved outcomes when compared with both SADs and tracheal intubation.[15–17] This has led to calls for a prospective, randomised clinical trial to determine which airway is best for OHCA.[18–20] Preliminary work for such a trial has now been undertaken. REVIVE-Airways (ISRCTN 18528625) is a recently completed feasibility study comparing usual airway care during OHCA with two commonly used SADs: the i-gel and the Laryngeal Mask Airway Supreme (LMAS).[21] Both the i-gel and the LMAS have been studied successfully in OHCA.[12,22,23]

Paramedics now use SADs routinely, and usual practice comprises a range of techniques and procedures; the best airway option may be different for different pre-hospital clinicians and different patients.[19] Moreover, there is a distinction between initial airway management and other airway interventions that may be adopted at different stages of resuscitation. That patients may have more than one airway device during resuscitation has been highlighted previously,[14,18,19] but the precise sequence of airway interventions has never been reported. This investigation describes data extracted from patients treated in the 'usual practice' arm of the REVIVE-Airways feasibility study. This data provides a unique opportunity to examine the usual airway management provided by paramedics during CPR for OHCA and the pathway of interventions made to sustain and secure ventilation in the pre-hospital environment.

2. Method

2.1. Setting

Data were collected from out of hospital cardiac arrests attended by South Western Ambulance Service North Division paramedics participating in the REVIVE-Airways feasibility study between March 2012 and February 2013, serving a total population of approximately 2.2 million people. Participating paramedics were randomised to one of three arms: the i-gel; the Laryngeal Mask Airway Supreme (LMAS); or Usual Practice. Randomation was stratified by years of experience and distance of the paramedic's ambulance base station from hospital.

2.2. Eligibility

Data were included if patients were attended by a paramedic randomised to the 'usual practice' arm of the REVIVE-Airways feasibility study, and the patient fulfilled the main study eligibility criteria (adults 18 years or older in non-traumatic OHCA and attempted resuscitation was indicated according to national guidelines), and the patient did not receive either of the intervention supraglottic airway devices (the i-gel or LMAS) at any time during the resuscitation attempt.

2.3. Data collection

Paramedics who consented to take part in REVIVE-Airways were randomised to one of the three study arms (usual practice, the i-gel or the LMAS). The process of randomisation was completed by a statistician independent of the trial using a computer-generated random number sequence, and allocation was fully concealed from the participating paramedics and research team.Randomisation was stratified by length of service and location of the paramedic's base station (distance from hospital). Analysis of groups post-randomisation indicated that there were no differences between groups in either length of service or distance of the paramedics base station from hospital. After randomisation, paramedics attended a two-hour training session to provide them with updates on resuscitation guidelines and the opportunity to rehearse airway management skills and wereinstructed to use their allocated method of airway management for each OHCA that they attended during the 12 month data collection period. Paramedics in the usual practice arm had access to the standard airway management equipment that was issued by the ambulance service at the time the study took place; bag valve mask, tracheal tubes and the Ambu AuraOnce Disposable Laryngeal Mask Airway. These paramedics were asked to continue to manage the airway as they would usually do in accordance with national and local guidelines and to complete a case record form (CRF) to detail the airway management techniques used for each eligible patient that they attended during the study period. The CRF contained fields for: method of initial airway management; ventilation success; presence and degree of air leak; incidence of regurgitation; further interventions made; reasons for any changes in the airway management technique.

3. Results

This was a cluster randomised trial; patients were enrolled according to the allocation of the paramedic treating them. Of 615 patients enrolled in REVIVE-Airways, 209 (34%) were randomised to usual practice and 198 (95%) received usual practice (did not receive either of the two intervention devices during the resuscitation attempt). These patients were attended by 49 of the 171 paramedics randomised to participate in REVIVE-Airways. The mean (standard deviation) number of patients attended per paramedic was 4.0 (2.6). The dataset was screened for individual paramedic practice, with no evidence that any individual was responsible for a significant proportion of the airway management changes made. The mean patient age was 70.7 years (standard deviation 14.6 years), and the other characteristics of the cardiac arrests are shown in Table 1.

Two of the 198 patients had return of spontaneous circulation/respiration (ROSC/R) by the time the paramedic arrived on scene, and required no advanced airway management; they were removed from the analysis. Data from 196 attempted resuscitations were therefore included in the analysis.

3.1. Initial airway management

Initial airway management was carried out using a bag-mask, SAD (Ambu® AuraOnce™ LMA) or tracheal tube (intubation). The numbers of patients receiving each method as the initial approach are shown in Table 2.

The initial method of airway management was bag-mask for 108 (55%), SAD for 39 (20%) and intubation for 49 (25%) of attempted resuscitations. Paramedics made further airway interventions in 64% of resuscitations: one intervention in 45%, two interventions in 15%, and three interventions in 4% of resuscitations. When

Table 1
Demographics of cardiac arrests included EMS - Emergency Medical Services; PEA - pulseless electrical activity; VF–ventricular fibrillation; VT–ventricular tachycardia; ROSC–return of spontaneous circulation.

Gender	Female	78	Male	114					Missing	6
Age (years)	Mean	70.7	Standard Deviation	14.6					Missing	13
Cause of arrest	Asphyxia	5	Presumed Cardiac	189	Other	1			Missing	3
Location of arrest	Ambulance	1	Nursing/Care Home	24	Usual residence	143	Public Place	27	Missing	3
Witnessed	No	68	Yes, by EMS	22	Yes, by non EMS	105			Missing	3
Bystander CPR	No	77	Yes	118					Missing	3
Bystander defibrillation	No	193	Yes	2					Missing	3
Initial rhythm	Asystole	87	PEA	29	VF/pulseless VT	41			Missing	41
Attempted defibrillation	No	102	Yes	58					Missing	38
Drugs administered	No	21	Yes	139					Missing	38
ROSC >30 seconds	No	113	Yes	80					Missing	5

Table 2
Initial airway management method and number of further interventions BMV–bag mask ventilation; SAD–supraglottic airway device.

Initial Airway Management	BMV (n = 108)		SAD (n = 39)		Intubation (n = 49)		Total (n = 196)	
No further intervention	17	16%	17	44%	37	76%	71	36%
Intervention needed	91	84%	22	56%	12	24%	125	64%
1 further intervention	59		19		10		88	
2 further interventions	26		2		2		30	
3 further interventions	6		1		0		7	

intubation was the initial approach, 76% required no further intervention; this compared to no further intervention in 16% and 44% when the BVM and SAD were used initially.

3.2. Further airway interventions

A change in airway management describes one strategy being abandoned, and an alternative method being adopted. In total there were 169 changes made to airway management involving 125 attempted resuscitations: 88 with 1 change, 30 with 2 changes and 7 with 3 changes.

The alternative strategy adopted when airway management was changed is shown in Table 3. Of 91 occasions where bag-mask was abandoned, the alternative was a SAD in 29 (32%) and intubation in 53 (58%) of cases. Of 41 occasions where a SAD or second SAD was removed during resuscitation, intubation was the subsequent strategy in 33 (80%) of cases. Of the 37 incidences where intubation or re-intubation was unsuccessful, a SAD was the alternative for 16 (43%) and a further intubation attempt was made in 13 (35%) of cases. Overall, intubation or re-intubation was the alternative method adopted for 94 (56%) of the 169 changes made, and a SAD was used as an alternative in 48 (28%) of changes.

Reasons for making a change to airway management are also shown in Table 3. The most common reason cited by paramedics for changing from bag-mask was to 'perform ALS' (Advanced Life Support); i.e. move to a more advanced airway management technique (41%), with half opting for intubation and half for a SAD. Inadequate ventilation was the reason given in 16% of cases; adequate ventilation was measured and defined as visible chest movement with each ventilation and audible air entry in both axillae on stethoscope auscultation. Regurgitation was cited as the reason for change in 31% of cases and intubation was the alternative method in 82% of patients who had inadequate ventilation or regurgitation. For patients with a first SAD, 'perform ALS' was the reason for change in 14% of patients, all of whom were subsequently intubated. A SAD was abandoned on 41 occasions and inadequate ventilation or problems with positioning were cited as the reasons for removing it in 19 (46%) cases. Displacement of a SAD occurred on five occasions in a total of three patients.

3.3. Intubation success

There were 143 attempted intubations or attempted re-intubations; 49 were undertaken as initial airway management (of which 12 were unsuccessful) and 94 intubations or re-intubations were subsequent to the initial approach. 29 of these 94 intubations or re-intubations were unsuccessful, while in five cases the tracheal tube displaced and in a further three it was intentionally removed because ROSC/R had been achieved.

4. Discussion

We have documented in detail the airway interventions undertaken by paramedics while resuscitating 196 OHCA patients, and have shown that they made more than one intervention in two-thirds of cases. Just over half of paramedics opted for a bag-mask as their initial airway management technique, with the others split between intubation and a SAD. However, where bag-mask was used as the initial technique an alternative was adopted subsequently in 84%, and in 30% of cases two or more changes were made. When intubation was attempted as the initial technique, a change in airway management was made in one quarter of cases, primarily due to failed intubation, and very few underwent more than one change. SADs fell somewhere between bag-mask and intubation in the subsequent use of alternative techniques. This implies that when a patient is successfully intubated as the initial approach to airway management it is usually definitive, whereas the bag-mask or SAD is used frequently as a 'stepping stone' to ventilate the patient until it becomes ineffective or the opportunity to intubate the patient arises. This approach has potential advantages: a simple airway technique used initially may enable paramedics to focus on chest compressions and defibrillation, moving to more advanced techniques when the situation has become more stable or following ROSC/R. However, changes in airway management may interrupt chest compressions, which is known to be detrimental to resuscitation success, so understanding the frequency and reason for such changes is valuable.

These data may also be interpreted by scrutinising all changes made, irrespective of when this occurred. When a bag-mask was abandoned, intubation was the alternative in the majority (58%) of cases, with a SAD used in about a third of changes. The propensity to

Table 3
Abandoned technique and reason with alternative method adopted BMV - bag mask ventilation; SAD–supraglottic airway device; ROSC/R–return of spontaneous circulation/respiration; ALS - advanced life support; HEMS–helicopter emergency medical service.

	Alternative method adopted									
Abandoned technique and reason	BMV	SAD	2nd SAD	Intubation	Reintub-ation	Reposit-ioned	**ROSC/R	Could not ventilate	Total	Percent-age
BMV		29		53			9		91	100%
Inadequate ventilation		6		9					15	16%
Regurgitation		5		23					28	31%
*Perform ALS		18		19					37	41%
**ROSC/R							9		9	10%
***HEMS				1					1	1%
Not given				1					1	1%
SAD	1		3	32		1	1		38	100%
Inadequate ventilation			1	15					16	42%
Regurgitation				7					7	18%
Displaced			2			1			3	8%
Unable to position	1			1					2	5%
*Perform ALS				5					5	13%
**ROSC/R							1		1	3%
***HEMS				4					4	11%
2nd SAD				1		2			3	100%
Inadequate ventilation				1					1	33%
Displaced						2			2	67%
Tracheal Intubation	3	14			8	5	3	1	34	100%
Failed intubation	3	14			8			1	26	76%
Displaced						5			5	15%
**ROSC/R							3		3	9%
Reintubation	1	2							3	100%
Failed intubation	1	2							3	100%
Grand Total	5	45	3	86	8	8	13	1	169	
Percentage	3%	27%	2%	51%	5%	5%	8%	1%	100%	

*Perform ALS: The paramedic decided to move to a more advanced airway management technique.
** ROSC/R: The airway device was removed because the patient had a return of spontaneous circulation.
***HEMS: A doctor-led pre-hospital critical care team arrived at scene, assumed patient care and made a change to airway management.

intubate increased once a SAD had proved unsuccessful, with subsequent intubation in 80% of cases. Conversely, when intubation proved unsuccessful, re-intubation was the chosen intervention in only a quarter of cases, with a SAD used as the alternative in 43%. Overall, if an airway technique proved unsuccessful intubation or re-intubation was the preferred alternative and accounted for over half of all the changes made, whereas the SAD was used as an alternative in just over a quarter of changes. Therefore, if a change in airway management occurred, paramedics in this study were twice as likely to intubate as they were to insert a SAD. However, when intubation was attempted after airway management with an alternative technique, the intubation failure rate was unexpectedly high at 29/94 (31%): this may be because problems encountered with one airway technique increase the likelihood of subsequent difficulty in tracheal intubation.

Most studies of airway management during OHCA are retrospective analyses that allocate patients into distinct groups (typically tracheal intubation, SAD insertion or bag-mask ventilation), and compare outcomes based on a single documented airway intervention.[14] Some investigators have dichotomised patients into basic (bag-mask) and advanced (tracheal intubation and SAD) airway management techniques.[15] Based on our findings, these studies may have artificially compartmentalised patients into single airway intervention groups, and do not address adequately the possibility that multiple airway devices may have been used. Thus, by associating an outcome with any single airway management technique, these observational studies are too simplistic. The optimal method for managing the airway during cardiac arrest may incorporate multiple techniques, and change as the resuscitation attempt proceeds.

A retrospective study that analysed separately those patients who had been exposed to both tracheal intubation and SAD insertion, whether successful or not concluded that tracheal intubation was associated with better outcomes.[14]

The incidence of regurgitation and aspiration is higher in OHCA than in-hospital cardiac arrest.[8,9] Paramedics cited regurgitation as the reason for making a change to BVM or SAD airway management in a quarter of cases, and intubation was the alternative for almost all of these. It is not clear whether the airway management changes were made because the regurgitation made ventilation impossible with a bag-mask or SAD, or because the paramedic was concerned about the risk of pulmonary aspiration, and therefore elected to protect the airway by tracheal intubation. Understanding the meaning of 'inadequate ventilation' as a reason cited for changing a SAD to an alternative technique would be a useful area for future research, especially if this is having a detrimental effect on the resuscitation attempt.

Paramedic experience, skills and beliefs are all likely to impact on their airway management decisions; however, a strength of our study is that the paramedics were randomised to one of three study arms, and the randomisation was stratified by experience and ambulance station location. This makes it likely that the paramedics in this study represented a wide range of clinicians. The reasons given by these paramedics for changing their airway management technique provide valuable insights into the merits and limitations of the various methods. For example, regurgitation was cited as the reason for abandoning a bag-mask in nearly one third of patients, compared with 18% for a SAD. In addition, displacement of a SAD proved to be an unexpectedly infrequent event.

There are several limitations to our work. Participating paramedics had access to only one type of SAD; other devices may have different properties, and the optimal SAD in OHCA has not yet been identified. In addition, the paramedics had volunteered to take part in a research study, and may not represent all practitioners in their preferences and skills. They had recently received airway refresher training, and knew that they would be reporting their actions during each OHCA they attended. Finally, these data rely on self-report, and were not independently verified. There were no

reports of unrecognised oesophageal intubation or other adverse events in this patient group, but we cannot exclude the possibility that reporting was incomplete.

This study arose from a unique opportunity to examine the actions taken by paramedics when they have access to tracheal tubes, SADs and bag-mask ventilation. Understanding usual practice is an important prerequisite to designing a randomised clinical trial (RCT) to determine definitively the optimal initial airway management strategy during out of hospital cardiac arrest. Prospective trials of airway management in OHCA that are properly powered for important clinical outcomes (e.g. neurological outcome at 6 months) are essential.

5. Conclusion

Paramedics use a range of airway management techniques during OHCA, switching between techniques as the resuscitation progresses. There is a tendency to move in a staged way to more advanced airway management techniques. Initial use of a bag-mask is often switched for an alternative technique during the arrest. Overall, 71% of tracheal intubation attempts were successful. It may be desirable to provide a range of airway options, supported by equipment and training, for use by paramedics attending OHCA. The optimal approach to initial airway management in OHCA remains unknown, and should be the subject of prospective randomised studies.

Conflicts of interest

Sarah Voss declares no conflicts of interest.
Megan Rhys declares no conflicts of interest.
David Coates declares no conflicts of interest.
Rosemary Greenwood declares no conflicts of interest.
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Matthew Thomas declares no conflicts of interest.
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Ethics and Patient Consent

National Research Ethics Service (NRES) approval for this trial was obtained from Cambridge Central Research Ethics Committee (11-EE-0407), and the trial is registered on the International Standard Randomised Controlled Trial Registry (ISRCTN: 18528625).

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Appendix A. Supplementary data

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