Influence of prehospital airway management on neurological outcome in patients transferred to a heart attack centre following out-of-hospital cardiac arrest

Abstract

Objective

To describe the association between prehospital airway management and neurological outcomes in patients transferred by the ambulance service directly to a heart attack centre (HAC) post ROSC.

Methods

A retrospective observational cohort study in which ambulance records were reviewed to determine prehospital airway management strategy and collect physiological and demographic data. HAC notes were obtained to determine in-hospital management and quantify neurological outcome via the Cerebral Performance Category (CPC) scale. Statistical analyses were performed via Chi-square, Mann-Whitney U test, odds ratios, and binomial logistic regression.

Results

220 patients were included between August 2013 and August 2014, with complete outcome data obtained for 209. Median age of patients with complete outcome data was 67 years and 71.3% were male (n=149). Airway management was provided using a supraglottic airway (SGA) in 72.7% of cases (n=152) with the remainder undergoing endotracheal intubation (ETI). There was no significant difference in the proportion of patients who had a good neurological outcome (CPC 1&2) at discharge between the SGA and ETI groups (p=.29). Binomial logistic regression incorporating factors known to influence outcome demonstrated no significant difference in neurological outcomes between the SGA and ETI groups (Adjusted OR 0.73, 95% CI 0.34-1.56).

Conclusion

In this observational study, there was no significant difference in the proportion of good neurological outcomes in patients managed with SGA versus ETI during cardiac arrest and in the post-ROSC transfer phase. Further research is required to provide more definitive evidence in relation to the optimal airway management strategy in out-of-hospital cardiac arrest.

Key Words

Resuscitation

Emergency Medical Services

Airway Management

Acute Coronary Syndrome

Introduction

The optimal airway management strategy in out-of-hospital cardiac arrest remains unclear (1). Some investigators report improved survival where endotracheal intubation (ETI) is performed by paramedics in cardiac arrest (2), whereas others have observed increased mortality (3). The emergence of alternative supraglottic airway (SGA) devices has led to calls for the withdrawal of paramedic ETI in favour of other techniques that may offer acceptable alternatives without the risks and complications associated with ETI (4). Other research suggests that the aetiology of the cardiac arrest (5) or the sequencing of the procedure with other resuscitation tasks (6) may be important factors in predicting the therapeutic value of ETI over other airway management approaches.

More recent research has addressed the care of patients who achieve return of spontaneous circulation (ROSC) after out-of-hospital cardiac arrest. Specialist Heart Attack Centres (HAC) capable of providing primary percutaneous coronary intervention (PPCI) in patients identified as meeting electrocardiographic criteria for myocardial infarction post ROSC have been established, with some evidence of improved outcomes (7). Establishment of these centres has often been at the expense of longer prehospital transfer times, placing additional demands on paramedics responsible for post-resuscitation care including airway management and ventilation (8). The influence of prehospital airway management and ventilation on outcomes are relatively well documented in the context of traumatic brain injury (9, 10). In contrast, no studies have evaluated these factors in patients transferred to a HAC following out-of-hospital cardiac arrest, despite the ongoing requirement for airway management and ventilation in a group with potentially treatable lesions but longer prehospital transfer times. The aim of this study was therefore to examine the effect of different airway management strategies on outcomes in out-of-hospital cardiac arrest patients who experienced ROSC and subsequent transfer to a HAC.

Design

We conducted a retrospective observational study, identifying patients on a month-by-month basis via an established ambulance service cardiac arrest registry and monitoring subsequent hospital course prospectively until discharge or death. Patients attended during 1st August 2013 to 31st August 2014 were included. Ambulance service clinical records were reviewed to determine patient demographics, key timings, airway management strategies and other therapeutic interventions. Hospital records including medical notes from HAC, intensive care and ward phases of care were reviewed to determine in-hospital management until death or discharge, with discharge records incorporating therapist assessment of functional status used to determine neurological outcome. Ethical approval for the study was granted by the National Research Ethics Service Committee (12/LO/1911) and by the Health Research Authority Confidentiality Advisory Group (CAG 1-06 PR6/2013) to permit processing of clinical data under limited conditions without informed consent. At the time of data collection, eight HAC were operational within the designated area, of which seven granted local research and development approval for participation in the study.

Setting

The London Ambulance Service (LAS) National Health Service (NHS) Trust serves a population of 8.2 million people distributed throughout an area of 1,579 km^2. Clinical care is provided by Emergency Medical Technician (EMT) level staff trained in intermediate life support which incorporates use of the i-gel SGA device, and paramedics trained in advanced life support incorporating ETI in some cases. Since 2011, patients with ROSC and evidence of ST Elevation Myocardial Infarction (STEMI) or presumed new onset Left Bundle Branch Block (LBBB) following out-of-hospital cardiac arrest undergo direct transfer to specialist HAC equipped to provide PPCI (11). These referrals are made autonomously by ambulance clinicians directly from the scene based on clinical presentation and interpretation of the prehospital 12 lead electrocardiograph (ECG) (12).

Participants

Adult (≥18 years) patients who suffered out-of-hospital cardiac arrest and achieved ROSC were eligible for inclusion where the resuscitation attempt involved active airway management and ventilation and the patient was transferred directly to a HAC. Cases where another healthcare professional such as a prehospital doctor managed the airway and those with prompt ROSC following defibrillation or chest compressions alone with no requirement for mechanical ventilation were excluded.

Data Collection

The primary outcome measure was neurological status assessed via Cerebral Performance Category (CPC), with good neurological outcome defined as CPC 1 or 2 (13). CPC was determined by a single researcher (TE) from review of medical, nursing and therapy notes consisting of physical, occupational and speech and language therapist assessments. Collectively these notes provide information regarding level of physical function and dependence in relation to activities of daily living as well as cognitive function. The primary variable of interest was prehospital airway management approach, stratified as basic measures alone (oropharyngeal and/or nasopharyngeal airways), insertion of an SGA, ETI, or a combination of techniques such as removal of SGA and subsequent ETI.

Sample size calculations were performed via G* Power (14, 15) with statistical significance set at $p < .05$ and power (1-beta) of 0.8 based on contingency table analysis (Chi Square) using Cohen's effect sizes (16). Historical data indicated 10-15 cases per month would be eligible for inclusion. On the basis of the four airway management approaches outlined above with initial outcomes stratified according to the five-point CPC scale, a sample of 193 patients were required to detect a ‘medium’ effect size. The target sample was increased (n=220) to allow for patients lost to follow-up.

Data were entered into IBM SPSS version 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp) for analysis. Patient demographics and clinical and physiological data were analysed using descriptive statistics including measures of central tendency (mean, median and mode) and measures of dispersion (standard deviation and range). Subsequent analyses were performed with statistical significance set at $p <.05$ (17). Initial analysis was undertaken with outcome data stratified by individual CPC category and subsequently using a binary classification of good (CPC 1&2) versus poor (CPC 3-5) neurological outcome (13). Chi-square testing was employed to examine differences in clinical and demographic categorical variables, firstly between the study sample with complete data available for analysis versus those lost to follow-up and secondly between patients from different airway management groups (18). Comparison of distribution for demographic and clinical variables was undertaken using the Mann-Whitney U test (16). This analysis was then repeated with outcome data stratified by individual CPC score using the Kruskal-Wallis test (18). Unadjusted and adjusted odds ratios were calculated to quantify the odds of good versus poor neurological outcome according to whether the patient was exposed to airway management via a supraglottic device or endotracheal tube (19). Initial outcome analysis was based on the final airway approach used in the prehospital phase, and then repeated on an intention-to treat-basis using the first attempted airway technique. These analyses were performed for all patients and then repeated for cases presenting in shockable and non-shockable rhythms. In the final phase of statistical analysis, the blockwise approach to binomial logistic regression whereby predictor values are entered systematically was employed to calculate adjusted odds ratios stratified by good (CPC 1&2) versus poor (CPC 3-5) outcome. The first model incorporated clinical variables identified as significantly associated with outcome in this study (time to ROSC, shockable rhythm and age) and the second core Utstein variables (witnessed arrest, bystander CPR and first monitored rhythm). A small number of variables were incorporated with the intention of producing parsimonious models in the context of the sample size.

Results

A total of 220 patients were included, with complete outcome data obtained for 95% (n=209). Insufficient clinical data to facilitate CPC scoring was available in seven patients and a further four were lost to follow up due to transfer to other hospitals not included in the study. There were no significant differences between patients included in the final sample versus those where outcome data were not available. The majority of patients with complete outcome data were male (n=149, 71.3%), presented in a shockable rhythm (n=135, 64.6%), suffered a witnessed cardiac arrest (n=172, 82.3%) and had bystander CPR performed (n=125, 59.8%). Median age was 67 years (range 22-96) and 28.3% (n=59) were classified as CPC 1 or 2 at discharge (Table 1). Patients were attended within a mean 6.5 minutes (SD 4.1) of the emergency call and mean time from arrival at scene to commencement of transfer to a HAC was less than an hour (56.3 minutes, SD 19.5). Clinical characteristics stratified by neurological outcome are show below (Table 2).

Airway management was most commonly undertaken using a supraglottic device (n=152, 72.7%) and no patients were managed using basic methods alone. In six cases a supraglottic airway was inserted after a failed ETI attempt and in a further sixteen cases a supraglottic airway was removed and replaced with an endotracheal tube. There were no significant differences in clinical characteristics between the between the SGA and ETI groups (Table 3). Odds of poor outcome with ETI versus SGA were not significant (OR 1.11, 95% CI 0.93-1.32). Increased odds of poor outcome with ETI were observed in patients presenting in a non-shockable rhythm (OR 1.11, 95% CI 1.01-1.28) but not in those presenting in a shockable rhythm (OR 1.01, 95% CI 0.74-1.39). Odds of poor outcome with ETI were not significant when adjusted for the presence of bystander CPR, witnessed arrest and shockable rhythm (Adjusted OR 0.84, 95% CI 0.34-3.13) or when incorporating time to ROSC, age and the presence of a shockable rhythm (Adjusted OR 0.90, 95% CI 0.37-2.19) (Table 4).

Discussion

Our study found no significant difference in the proportions of good versus poor neurological outcome stratified by airway management approach in a cohort of patients with ROSC following out-of-hospital cardiac arrest who underwent direct transfer to a HAC. Earlier studies investigating the influence of airway management on survival in out-of-hospital cardiac arrest have identified either no difference in outcomes between different airway management approaches (20), or a trend towards worse outcomes associated with any form of advanced airway management versus basic measures alone (3, 21). In these studies, adjusted odds of improved outcome in patients not exposed to ETI range from 2.33 (95% CI 1.63-3.33) (21) to 4.5 (95% CI 2.3-8.9) (3). Multivariate analysis by Egly et al. found that ETI significantly decreased survival to discharge in patients presenting in a shockable rhythm (Adjusted OR 0.52, 95% CI 0.27-0.998) but increased survival to admission in those with non-shockable rhythms (Adjusted OR 2.94, 95% CI 1.16-7.44) (20). Our study found no significant difference in adjusted odds of poor outcome with ETI versus SGA in two binomial logistic regression models incorporating Utstein predictors and variables identified as significantly associated with outcome in this dataset.

Variation in Emergency Medical Services (EMS) renders meaningful comparison with other studies challenging. The resuscitation populations included in these studies are also more heterogenous which contrasts with the relatively homogenous sample of post-ROSC patients with evidence of STEMI in our study. The inability to control for time to ROSC in many studies is a major limiting factor, given that shorter time to ROSC is associated with improved outcomes (22) and a reduced requirement for advanced airway management. Data collection for these studies also occurred prior to important revisions in international resuscitation guidelines, which refocussed attention on the provision of high quality chest compressions and de-emphasised advanced airway management, particularly where this might result in interruptions to compressions (23). Data relating to both time to ROSC and age were collated and identified as significant predictors of survival in our study, enabling their incorporation as part of binomial regression analyses. Missing data may also compromise results, with Arslan Hanif et al. reporting missing discharge data for 16% (n=48) of patients, all of whom were categorised as having poor outcome in subsequent analyses (3) compared with 5% of patients lost to follow up in our study.

Two registry analyses of outcomes in cardiac arrest have identified small but significant improvement in odds of good neurological outcome associated with ETI versus SGA (2, 24). In keeping with the approach adopted in the current study, these analyses compared ETI with SGA insertion, although a wider range of supraglottic devices were in use and the populations were again more heterogenous in terms of both EMS system (25) and aetiology. Previous CARES registry analysis by McMullan et al. demonstrated that ETI was associated with a higher sustained ROSC rate(OR 1.35, 95% CI 1.19-1.54), survival to hospital admission(OR 1.36, 95% CI 1.19-1.55), hospital survival (OR 1.41, 95% CI 1.14-1.76) and hospital and discharge with good neurologic outcome (OR 1.44, 95% CI 1.10-1.88) when compared with cases managed via SGA (2). Similarly, ROC PRIMED analysis (24) found that ETI was associated with increased survival to hospital discharge (adjusted OR 1.40, 95% CI 1.04-1.89), ROSC (adjusted OR 1.78, 95% CI 1.54-2.04) and 24-hour survival (adjusted OR 1.74, 95% CI 1.49-2.04). McMullan et al. further identified that patients managed via basic airway manoeuvres alone versus those undergoing ETI or SGA insertion exhibited higher adjusted odds of survival to discharge with good neurological outcome(adjusted OR 4.19, 95% CI 3.09-5.70), however time to ROSC was not incorporated in multivariate analyses. It may therefore be that airway management via basic means alone is a marker for shorter to time ROSC which is a predictor of improved neurological outcome (22). In contrast, a recent randomised controlled trial of ventilation via bag-valve-mask versus ETI in out-of-hospital cardiac arrest in a physician-led EMS system failed to demonstrate any significant difference in neurological outcomes (26). In addition, much higher proportions of patients underwent ETI versus SGA insertion in both the CARES (81.2% versus 18.8%) and ROC PRIMED (52.6% versus 29.3%) studies when compared with data from our study (27.3% versus 72.7%).

Limitations

Our study exclusively included patients fulfilling post ROSC criteria for transfer to a HAC and therefore cannot be generalised to different resuscitation populations, cardiac arrest aetiologies, and EMS systems. Study inclusion criteria resulted in a sample size which may have been underpowered to detect a clinically significant effect, however this was limited by the volume of post-ROSC patients transferred to HAC during the study period. Accuracy of prehospital ECG interpretation and adherence to guidelines were not assessed and therefore some patients may have been inappropriately transferred to a HAC. Variation in treatment between individual HAC was not analysed, although the study was conducted within a single HAC network with unified admission criteria. Use of a single researcher to assess CPC has the potential to bias results given previously identified inter-rater variability in CPC scoring (27). Not all paramedics within the participating EMS system are authorised to perform ETI, therefore it was not possible to consistently determine whether an intubation-trained paramedic was present at the scene.

Conclusion

In this study, there was no significant difference in the proportion of good neurological outcomes in patients managed with SGA versus ETI during cardiac arrest and in the post-ROSC transfer phase. Further research focussing on post resuscitation care is required to provide more definitive evidence in relation to the optimal airway management strategy in patients undergoing direct transfer to a HAC.

Conflicts of interest: None

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Tables

Table 1 Cerebral Performance Category at discharge

	CPC1	CPC2	CPC3	CPC4	CPC5
Number of cases (%)	43 (20.6%)	16 (7.7%)	15 (7.2%)	7 (3.3%)	128 (61.2%)

Table 2 Clinical and demographic variables stratified by neurological outcome

	Good Outcome (CPC 1&2)	Poor Outcome (CPC 3-5)	p value
Male	47 (79.7%)	102 (68.0%)	.13
Witnessed Arrest	49 (83.1%)	123 (82.0%)	1.00
Bystander CPR	41 (69.5%)	84 (56.0%)	.102
Shockable Rhythm	54 (91.5%)	81 (54.0%)	<.001
Advanced Paramedic	5 (8.5%)	13 (8.7%)	1.00
Angiography Performed	54 (91.5%)	97 (65.5%)	<.001
Any SBP < 90mmHg	0 (0%)	17 (11.3%)	.01
Post ROSC Adrenaline	1 (1.7%)	45 (30.0%)	<.001
Age (years)*	61 (22-85)	69 (34-96)	<.001
Arrival of first resource to airway placement (minutes)*	10 (2-41)	11 (1-43)	.46
Call to arrival of first resource (minutes)*	6 (1-13)	6 (1-48)	.90
Arrival of first resource to CPR (minutes)*	2 (0-28)	2 (0-32)	.52
Arrival of first resource to ROSC (minutes)*	16 (5-48)	27 (6-87)	<.001
Arrival of first resource to departure to HAC (minutes)*	45 (7-95)	57 (17-143)	<.001
Transfer time to HAC (minutes)*	14 (1-49)	14 (2-40)	.30
Tympanic temperature (^{o}C)*	35.5 (12.2-37)	35.6 (30-37.7)	.44
Blood capillary glucose (mmol/l)*	8.6 (1.9-27.7)	8.9 (3.3-24.6)	.24
Highest recorded ETCO2 (kPa)*	4.4 (2.7-9)	4.8 (1.3-13.3)	.04
First Recorded SBP*	134 (91-209)	128 (56-210)	.22

*Median (Range)

Table 3 Clinical and demographic variables stratified by final airway management approach

	ETI (n=57)	**SGA (n=152)**	**p value**
Male	42 (73.7%)	107 (70.4%)	.77
Witnessed Arrest	44 (77.2%)	128 (84.2%)	.33
Bystander CPR	35 (61.4%)	90 (59.2%)	.90
Shockable Rhythm	33 (57.9%)	102 (67.1%)	.28
Advanced Paramedic	6 (10.5%)	12 (7.9%)	.55
Angiography Performed	38 (66.7%)	113 (75.3%)	.74
Age (years)	68 (22-96)	66 (34-93)	.30
Age (years)*	11 (1-43)	10 (1-33)	.14
Arrival of first resource to airway placement (minutes)*	6 (2-17)	6 (1-48)	.27
Call to arrival of first resource (minutes)*	2 (0-9)	2 (0-32)	.72
Arrival of first resource to CPR (minutes)*	25 (5-79)	24 (6-87)	.37
Arrival of first resource to ROSC (minutes)*	54 (31-92)	55 (7-143)	.61
Arrival of first resource to departure to HAC (minutes)*	14 (4-43)	14 (1-49)	.94
Transfer time to HAC (minutes)*	35.6 (34.1-37)	35.6 (12.2-37.7)	.91
Tympanic temperature (ºC)*	9 (3.8-27.7)	8.8 (1.9-27.7)	.64
Blood capillary glucose (mmol/l)*	90 (7-150)	96 (0-222)	.19
Highest recorded ETCO2 (kPa)*	128 (75-203)	130 (56-210)	.70
First Recorded SBP*	4.1 (1.3-9.5)	4.3 (0.9-13.3)	.83

* Median (Range)

Table 4 Odds of poor outcome with ETI versus SGA

	Odds Ratio	95% CI Lower	95% CI Upper
Unadjusted -All cases	1.07	0.93	1.32
Unadjusted – Non-shockable cases	1.11	1.01	1.28
Unadjusted – Shockable cases	1.01	0.74	1.40
Adjusted (bystander CPR, witnessed arrest, shockable rhythm)	0.84	0.34	3.13
Adjusted (time to ROSC, age, shockable rhythm)	0.90	0.37	2.19