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ORIGINAL ARTICLE

Dose pre-hospital laryngeal mask airway use has a survival benefit in non-shockable cardiac arrest?

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ABSTRACT

Background. Whether pre-hospital laryngeal mask airway (LMA) use poses a survival benefit and should be approved as routine airway management in non-shockable cardiac arrest is of major concern. The present study examined the effectiveness of LMA, in comparison to other pre-hospital airway management on individuals who have experienced non-shockable cardiac arrest.

Methods. Adult patients who experienced non-shockable cardiac arrest with activation of the emergency medical service (EMS) made up our study cohort in Taoyuan, Taiwan. The data were abstracted from EMS records and cardiac arrest registration protocols.

Results. Among the 1912 enrolled patients, most received LMA insertion (72.4%), 108 (5.6%) bag-valve-mask (BVM) ventilation, 376 (19.7%) high-flow oxygen non-rebreather facemask, and only 44 (2.3%) received endotracheal tube intubation (ETI). With regard to survival to discharge, no significant differences in prevalence were evident among the groups: 2.8% of oxygen facial mask, 1.1% of BVM, 2.1% of LMA, and 4.5% of the ETI group survived to discharge (p = 0.314). In comparison to oxygen facial mask use, different types of airway management remained unassociated with survival to discharge after adjusting for variables by logistic regression analysis (BVM: 95% confidence interval [CI], 0.079 – 1.639 [p = 0.186]; LMA: 95% CI, 0.220–2.487 [p = 0.627]; ETI: 95% CI, 0.325–17.820 [p = 0.390]). The results of Hosmer-Lemeshow goodness-of-fit test of logistic regression model revealed good calibration.

Conclusions. Pre-hospital LMA use was not associated with additional survival to discharge compared with facial oxygen mask, BVM, or ETI following non-shockable cardiac arrest.

Key words: emergency medical service, out-of-hospital cardiac arrest, laryngeal mask airway, ventilation, cardiopulmonary resuscitation

Introduction

Background

According to established guidelines on the resuscitation of individuals who experience out-of-hospital cardiac arrest (OHCA), the airway should be established with adequate ventilation. (1-3) Options for emergent airway management include facial oxygen mask with passive insufflation, bag-valve-mask ventilation (BVM), laryngeal mask airway (LMA), or endotracheal tube intubation (ETI) with positive pressure ventilation. The LMA is easy to use, has the potential for rapid application, and has proof that such devices can be used safely and properly by emergency medical technicians (EMT) during pre-hospital scenarios. (4-7) Previous studies have shown that LMA provided greater lung tidal volume but less stomach inflation or regurgitation than BVM ventilation. (8-11) Besides, ventilation via LMA, which enables direct bagging without the need to change hand position for sealing the mask, minimizes interruptions in chest compressions and provides enhanced ventilation during transport. (12) Few studies have compared OHCA outcomes as endpoints in patients who received various types of airway management. The study group "Survey of survivors of out-of-hospital cardiac arrest in the Kanto region of Japan" and Shin et al. failed to demonstrate benefits of LMA when used during the pre-hospital period of witnessed OHCAs. (13,14) Hasegawa et al. reported a decrease of favorable outcomes while using advan-

ced airway management compared with conventional BVM ventilation. (15) With regard to witnessed ventricular fibrillation, Bobrow et al. reported that passive oxygen insufflation via facemask is superior to BVM ventilation. (16) Instead of receiving assistance to establish an airway with additional ventilation, the victims of witnessed collapse may benefit from delayed airway management and uninterrupted chest compression. This inference is based on the assumption that blood oxygen levels are fully saturated during the initial minutes following cardiac arrest. Therefore, the restoration of circulation rather than airway management yields better outcomes.

In contrast, little is known about the effects that result from the use of different airway management and ventilation practices during pre-hospital resuscitation procedures on individuals who experience a non-shockable rhythm. These patients may experience prolonged arrest, ceased circulation, and blood oxygen desaturation. In addition, cardiac arrest in these cases sometimes originates from airway and respiratory etiologies, such as upper airway obstruction or severe asthma. (17,18) Therefore, the establishment of an airway with adequate ventilation poses a major concern. (19) The effectiveness of LMA ventilation in pre-hospital resuscitation for cases of non-shockable cardiac arrest has not been verified.

Importance

Whether pre-hospital LMA use poses a survival benefit and should be approved as routine airway management in non-shockable cardiac arrest is of major concern. The scientific community needs to explore the association between different methods of ventilation and successful resuscitation.

Goals of this investigation

The present study examined: 1. pre-hospital LMA use on individuals who have experienced non-shockable cardiac arrest and 2. the effectiveness of LMA, in comparison to using high-flow oxygen, non-rebreather facemasks with passive insufflation, BVM ventilation, or ETI by EMTs with positive pressure ventilation. For these types of patients, we hypothesized that LMA with positive pressure ventilation would be most effective.

Materials and methods

Study design and setting

For this study, we prospectively defined a retrospective review of a database. This study was approved by the hospital's ethics committee on human research. The study protocol was reviewed and it was determined to be exempt from the requirement to obtain informed consent.

The study was conducted in Taoyuan County of northern Taiwan, which has a population of 1,958,686 residents; population density is 1,605 persons per square kilometer. (20) This region contains 35 emergency medical system (EMS) branches, 1 medical center, and 10 local hospitals. The incidence of non-traumatic OHCA in adults is estimated at 1,000 cases per year. EMTs function as the primary providers of pre-hospital emergency care.

In Taiwan, EMTs are classified as EMT-1 (EMT-basic in the United States), EMT-2 (EMT-intermediate in the United States), and EMT-paramedic (EMT-P). EMT-1, EMT-2, and EMT-P personnel receive 40, 280, or 1,280 hours of training, respectively, prior to certification, and they receive continued education for 24, 72, or 96 hours, respectively, every 3 years. According to our legislation, ETI should be performed by board-certificated EMT-P personnel only. EMT-2 and EMT-P personnel decide at their discretion to use LMA. In 2010, 104 EMT-1, 666 EMT-2, and 36 EMT-P personnel were employed at various EMS stations in Taoyuan County.

After receiving an emergency call, a centralized dispatch center activates the nearest EMS branch, which sends an ambulance and 2–3 EMTs to the site of the incident. The EMTs are not permitted to declare death or terminate resuscitation unless the patient is decapitated, incinerated, or decomposed or displays signs of rigor mortis. However, resuscitation is attempted at the request of family members. The EMTs transport the patient to a nearby hospital regardless of whether return of spontaneous circulation (ROSC) is achieved at the scene. Advanced cardiac life support and post-resuscitation care are administered according to the 2010 American Heart Association guidelines after patient arrival at the emergency department (ED). (1) Patients are declared dead if ROSC is not achieved after 30 min of resuscitation in the ED. Patients with sustained ROSC, which is defined as signs of circulation that persist without chest compressions for 20 consecutive minutes, are admitted to the intensive care unit (ICU) as indicated. (21)

Participant selection

Between June 2011 and November 2012, we included adult patients who were at least 18 years of age and experienced non-traumatic cardiac arrest as identified by the activation of EMS. Exclusion criteria included patients who experienced shockable rhythm by automated external defibrillator (AED) and patients with incomplete records.

Interventions

Patients were separated into four groups based on airway management used during pre-hospital resuscitation. Patients who received high-flow oxygen non-rebreather facemask with passive insufflation, BVM ventilation, LMA, or ETI with positive pressure ventilation were assigned to groups 1, 2, 3 and 4, respectively.

All participants had experienced non-shockable cardiac arrest, and patients had received CPR in preparation for the attachment of the AED after cardiac arrest was confirmed at the scene. CPR was then continued after a non-shockable rhythm was detected. For group 1, EMTs had performed uninterrupted chest compression, and the patient was transported directly to the hospital. In addition, an oral or nasal airway was inserted for these patients. In groups 2, 3 and 4, chest compression and ventilation were applied at a frequency of 30:2, and intravenous epinephrine was administered via successfully established venous access by a board-certified

Table 1. Baseline characteristics of patients who received different airway management and ventilation during pre-hospital period.

	Group 1[a] N = 108	Group 2[b] N = 376	Group 3[c] N = 1384	Group 4[d] N = 44
Male, N (%)	58 (53.7)	261 (69.4)	909 (65.7)	32 (72.7)
Age in years; median (IQR)	69.5 (55.0 – 82.8)	71.0 (52.0 – 83.0)	75.0 (60.0 – 84.0)	73.5 (57.3 – 84.8)
Place of event, N (%)				
Home	90 (83.3)	315 (83.8)	1212 (87.6)	34 (77.3)
Public place	2 (1.9)	6 (1.6)	11 (0.8)	1 (2.3)
Street	2 (1.9)	9 (2.4)	41 (3.0)	1 (2.3)
Nursing home	4 (3.8)	18 (4.8)	36 (2.6)	3 (6.8)
Workplace	2 (1.9)	10 (2.7)	29 (2.1)	1 (2.3)
Others	8 (7.4)	18 (4.8)	55 (4.0)	4 (9.1)
Witnessed collapse, N (%)	47 (43.5)	174 (46.3)	607 (43.9)	19 (43.2)
Bystander CPR, N (%)	23 (21.3)	89 (23.7)	322 (23.3)	16 (36.4)
Intravenous epinephrine injection, N (%)	1 (0.9)	3 (0.8)	34 (2.5)	25 (56.8)
Timeliness of pre-hospital care in minutes, median (IQR)				
Response interval	6.0 (4.0 – 8.0)	6.0 (4.0 – 7.0)	6.0 (4.0 – 8.0)	5.0 (4.0 – 7.0)
Duration at scene	10.0 (7.0 – 13.0)	10.0 (8.0 – 13.0)	11.0 (9.0 – 14.0)	16.0 (12.3 – 20.8)
Transport interval	6.0 (3.0 – 9.0)	5.0 (3.0 – 9.0)	5.0 (3.0 – 9.0)	5.0 (3.0 – 7.8)

CPR, cardiopulmonary resuscitation; IQR, interquartile range.
[a] Group 1: Patients who received high-flow oxygen non-rebreather facemask with passive insufflation.
[b] Group 2: Patients who received bag-valve-mask ventilation.
[c] Group 3: Patients who received laryngeal mask airway with positive pressure ventilation.
[d] Group 4: Patients who received endotracheal tube intubation with positive pressure ventilation.

EMT-P if present. EMT-2 and EMT-P personnel are trained for LMA insertion. They underwent a 3-hour instruction course on LMA application, including LMA insertion practice on manikins. They then performed LMA insertion during their daily practice. Appropriate positioning of the LMA or endotracheal tube was checked by physical examination, including symmetric expansion during ventilation and chest auscultation.

Data collection and outcome measures

The authors reviewed the records and conducted data abstraction using the Utstein style of reporting guidelines, which uses clear definitions and codes. (21) Demographic data and pre-hospital covariates were collected from the EMS record, including age and sex of the patient, time and place of the events, presence of a witness, CPR application by bystanders, the application of AED shock, methods of airway management used, and the timeliness of pre-hospital care (i.e., response interval, duration of care administered at the scene, and transport interval).

Patient outcomes were abstracted via OHCA registration maintained at each of the hospitals. The primary outcome was survival to discharge (i.e., patient is alive at discharge or was transferred successfully to a long-term care center). Other outcome measures included ROSC achieved before arrival at the ED and survival for 24 h.

Primary data analysis

We compared groups for demographic characteristics and outcomes. Logistic regression was applied to identify independent associations between the type of airway management used and the primary outcome after other variables were adjusted.

Data were analyzed using SPSS 13.0 for Windows (SPSS; Chicago, IL). Categorical variables are presented as numbers and percentages, and were compared using the chi-squared or Fisher exact test as appropriate. Continuous variables are presented as medians and interquartile range (IQR). The Kruskal-Wallis H-test was used for non-normally distributed continuous variables. In all analyses, a p value less than 0.05 indicated statistical significance.

Results

Characteristics of study subjects

During the study period, a total of 3235

Table 2. Outcomes between groups.

	Group 1[a] N = 108	Group 2[b] N = 376	Group 3[c] N = 1384	Group 4[d] N = 44	p-value
ROSC achieved before arrival at ED, N (%)	2 (1.9)	6 (1.6)	11 (0.8)	3 (6.8)	0.002
Survival for 24 hours, N (%)	18 (16.7)	71 (18.9)	235 (17.0)	9 (20.5)	0.784
Survival to discharge, N (%)	3 (2.8)	4 (1.1)	29 (2.1)	2 (4.5)	0.314

ED, emergency department; ROSC, return of spontaneous circulation.
[a] Group 1: Patients who received high-flow oxygen non-rebreather facemask with passive insufflation.
[b] Group 2: Patients who received bag-valve-mask ventilation.
[c] Group 3: Patients who received laryngeal mask airway with positive pressure ventilation.
[d] Group 4: Patients who received endotracheal tube intubation with positive pressure ventilation.
Variables were tested using the Chi-square test.

adult patients experienced OHCA that led to the activation of EMS. Of these patients, 1323 were excluded because of the following exclusion criteria: 604 received no resuscitation attempts and were declared dead at the scene, 434 collapses were related to obvious trauma, 52 were lost to follow-up and no outcome was measured, 13 had an incomplete record of airway management, 50 were less than 18 years old, and 170 experienced a shockable rhythm. Of the 1912 remaining patients, most received LMA insertion (72.4%), 108 (5.6%) BVM ventilation, 376 (19.7%) high-flow oxygen non-rebreather facemask, and only 44 (2.3%) received ETI (figure 1).

The baseline characteristics of patients who received different types of airway management and ventilation during the pre-hospital period are shown in table 1. More men (65.9%) were included and the median age was 74.0 years (IQR, 57.0–82.0 years). Most events occurred at home (86.3%). 44.3% of patients suffered from witnessed collapse, but only 450 (23.5%) had received bystander CPR.

Of the patients who received ETI, 56.8% (25/44) also received intravenous epinephrine injections. The duration of care administered at the scene was significantly greater in the LMA and ETI groups (median time: 11.0 and 16.0 min, respectively) compared to the other groups (median time of both groups 1 and 2: 10.0 min). In contrast, the response and transport intervals were similar among groups.

Table 3. Variables independently associated with survival to discharge through logistic regression analysis.

	Odds Ratio (95% CI)	p-value
Witnessed collapse	3.766 (1.808– 7.846)	< .001
Bystander CPR	0.697 (0.313 – 1.551)	0.377
Intravenous epinephrine injection	0.472 (0.049 – 4.681)	0.517
High-flow oxygen non-rebreather facemask with passive insufflation	-	-
BVM with ventilation	0.359 (0.079 – 1.639)	0.186
LMA with positive pressure ventilation	0.740 (0.220 – 2.487)	0.627
ETI with positive pressure ventilation	2.407 (0.325 – 17.820)	0.390

BVM, bag-valve-mask; ETI, endotracheal tube intubation; CPR, cardiopulmonary resuscitation; LMA, laryngeal mask airway.

Main results

Among the 1912 enrolled patients, 22 (1.2%) achieved ROSC before arrival at the ED, 333 (17.4%) survived for 24 h, and only 38 (2.0%) survived to discharge. Among survivors, 14 were categorized as cerebral performance category scales 1 and 2. Table 2 demonstrated the outcomes between groups. With regard to survival to discharge, no significant differences in prevalence were evident among the groups: 2.8% of oxygen facial mask, 1.1% of BVM, 2.1% of LMA, and 4.5% of the ETI group survived to discharge ($p = 0.314$). Logistic regression was used to identify independent associations among types of airway management used and survival to discharge after variables were adjusted, including witnessed collapse, bystander CPR, and intravenous epinephrine injection (table 3). After the variables were adjusted for, different types of airway management remained unassociated with survival to discharge (BVM: 95% confidence interval [CI], 0.079 – 1.639 [$p = 0.186$]; LMA: 95% CI, 0.220–2.487 [$p = 0.627$]; ETI: 95% CI, 0.325–17.820 [$p = 0.390$]). The results of Hosmer-Lemeshow goodness-of-fit test of logistic regression model revealed good calibration with no significant differences between observed and predicted survival.

Discussion

Pre-hospital LMA use showed no additional survival benefit following non-shockable cardiac arrest

According to our study results, LMA use showed no additional survival benefit compared to other methods. Not only survival to discharge, but also 24-h survival was not associated with pre-hospital LMA use. Our findings have several potential explanations. First, individuals who have suffered a non-shockable cardiac arrest may experience longer periods of suspended circulation, breathing, and ventilation. Prolonged arrest

may lead to decreases in blood oxygen and tissue ischemia. Ocker et al. and Dorges et al. both reported that LMA use yields lung tidal volumes and peak airway pressures that are significantly better than those achieved with BVM ventilation. (9-11) Although ventilation is essential to the achievement of effective resuscitation, (19,22,23) these patients were gravely ill and unable to respond to resuscitation with LMA use. Therefore, our results demonstrated that witnessed collapse might have a greater influence on survival than airway management. Second, some patients' conditions may have a respiratory etiology, such as upper airway obstruction or severe asthma. (17,18) In addition to prolonged arrest, patients who developed cardiac arrest due to respiratory or airway origin might have a worse baseline health status. These all contributed to the failure of resuscitation, regardless of LMA use. Third, the difference in the survival benefit among LMA, BVM, and facemask use might be too small to be clinically significant. LMA use kept EMTs from needing to change position to seal the mask, minimized the interruption of chest compressions, and provided enhanced ventilation during transport. (12) Besides, previous studies have shown that LMA use results in less esophageal pressure, decreased gastric tidal volume, and less regurgitation during CPR compared to BVM ventilation. (8-11) However, with high-quality CPR, these advantages might have limited influence on outcomes. Even though further large studies might identify a significant difference in survival benefit of LMA use, we believe it is too small to be clinically significant. Fourth, there might have been some false positions and esophageal intubation in our study. No independent observer checked LMA position and function constantly during the study period. Thus, we were unable to report the success rate of LMA insertion by EMTs. A failed LMA insertion would not provide the advantages we expected and would result in limited benefit. If there was no survival benefit of LMA use by such trained and experienced airway providers, routine use of LMA in such conditions should be reconsidered. Further objective detectors such as capnography to confirm the position and function of LMA should be applied. In conclusion, LMA use showed no additional survival benefit compared to other methods. We cannot recommend routine use of LMA in non-shockable cardiac arrest.

We could not conclude that any specific type of airway management has a survival benefit following non-shockable cardiac arrest. Patients receiving ETI might be 2.4 times more likely to survive to discharge than those treated by high-flow oxygen non-rebreather facemask use, but the difference was not statistically significant (95%CI, 0.325–17.820 Šp = 0.390Ć). There were only 44 individuals who received ETI in our study. Over half of these patients also received intravenous epinephrine injection at the scene. Besides, all EMTs did not wait for field ROSC but sent patients directly to the hospital after completing their tasks, including ETI, if performed. Therefore, a further large study should be performed to verify the benefit of ETI use in such circumstances.

Sparse survival to discharge status in cases of non-shockable cardiac arrest

In our study, few patients survived to discharge (2.0%). Several factors may have contributed to this outcome. First, non-shockable cardiac arrest typically results in grave outcomes. In previous studies, for patients whose initial rhythm was asystole, the likelihood of successful resuscitation was low; 10% of these patients survived until hospital admission and less than 2% survived to discharge. (24-26) Second, most of our study population was elderly, with a median age of 74.0 years. This patient group is less able to respond to resuscitation efforts than others. Third, most of the events occurred at home (86.3%) in our study. Therefore, no AED was available before EMT arrival. No immediate defibrillation resulted in non-shockable rhythms after EMT arrival and led to poor outcomes. Fourth, even though 23.5% of patients had received bystander CPR, its quality was not measured. A previous study reported that good bystander CPR was associated with better outcomes compared to poor bystander CPR. (27) Thus, it is the quality rather than whether bystander CPR is performed that can be a pivotal factor.

Limitations

The present study should be interpreted in the context of several limitations. First, selection bias may have occurred due to the retrospective design and large number of patients excluded. In accordance with the strict and clearly defined criteria, all enrolled patients had experienced non-shockable cardiac arrest. Second, unmeasured confounding factors might exist. We made every effort to collect variables that offer potential correlation with our results according to the Utstein style of reporting guidelines. (21) Third, our study population was confined to county-based EMS records and cardiac arrest registration from a limited period of time, which may have limited the general applicability of our findings. Fourth, because of limited survival outcomes, we were unable to determine optimal pre-hospital airway management.

Conclusions

Pre-hospital LMA use was not associated with additional survival to discharge compared with facial oxygen mask, BVM, or ETI following non-shockable cardiac arrest.

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