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# Advanced Airway Management Does Not Improve Outcome of Out-of-hospital Cardiac Arrest

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## Abstract

**Background:** The goal of out-of-hospital endotracheal intubation (ETI) is to reduce mortality and morbidity for patients with airway and ventilatory compromise. Yet several studies, mostly involving trauma patients, have demonstrated similar or worse neurologic outcomes and survival-to-hospital discharge rates after out-of-hospital ETI. To date, there is no study comparing out-of-hospital ETI to bag-valve-mask (BVM) ventilation for the outcome of survival to hospital discharge among nontraumatic adult out-of-hospital cardiac arrest (OOHCA) patients.

**Objectives:** The objective was to compare survival to hospital discharge among adult OOHCA patients receiving ETI to those managed with BVM.

**Methods:** In this retrospective cohort study, the records of all OOHCA patients presenting to a municipal teaching hospital from November 1, 1994, through June 30, 2008, were reviewed. The type of field airway provided, age, sex, race, rhythm on paramedic arrival, presence of bystander cardiopulmonary resuscitation (CPR), whether the arrest was witnessed, site of arrest, return of spontaneous circulation (ROSC), survival to hospital admission, comorbid illnesses, and survival to hospital discharge were noted. A univariate odds ratio (OR) was first computed to describe the association between the type of airway and survival to hospital discharge. A multivariable logistic regression analysis was performed, adjusting for rhythm, bystander CPR, and whether the arrest was witnessed.

**Results:** A cohort of 1,294 arrests was evaluated. A total of 1,027 (79.4%) received ETI, while 131 (10.1%) had BVM, 131 (10.1%) had either a Combitube or an esophageal obturator airway, and five (0.4%) had incomplete prehospital records. Fifty-five of 1,294 (4.3%) survived to hospital discharge; there were no survivors in the Combitube/esophageal obturator airway cohort. Even after multivariable adjustment for age, sex, site of arrest, bystander CPR, witnessed arrest, and rhythm on paramedic arrival, the OR for survival to hospital discharge for BVM versus ETI was 4.5 (95% confidence interval [CI] = 2.3–8.9;  $p < 0.0001$ ).

**Conclusions:** In this cohort, when compared to BVM ventilation, advanced airway methods were associated with decreased survival to hospital discharge among adult nontraumatic OOHCA patients.

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Prehospital airway management is a priority for emergency medical services (EMS) personnel, and endotracheal intubation (ETI) has been long

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considered the criterion standard for securing the airway. Although EMS personnel routinely perform out-of-hospital ETI, there are several studies in the trauma literature that demonstrate little difference in survival outcome when ETI is compared to bag-valve-mask (BVM) ventilation.<sup>1–10</sup> Additionally, there are few randomized controlled trials (RCTs) that compare ETI to other airway management devices<sup>11,12</sup> for nontraumatic adult out-of-hospital cardiac arrests (OOHCA). The recent focus of cardiopulmonary resuscitation (CPR) and defibrillation as the primary interventions to improve survival for OOHCA patients has called into question the effectiveness of field ETI in reducing patient mortality and morbidity in nontraumatic cardiac arrest.<sup>13</sup> Time

spent for ETI in the field may be better spent focusing on the provision of optimal CPR, which confers survival benefit for OOHCA.

More specifically, ETI has not been compared to BVM for the outcome of survival to hospital discharge in adult nontraumatic OOHCA. An RCT evaluating ETI versus BVM for pediatric nontraumatic OOHCA,<sup>14</sup> however, demonstrated no survival or neurologic benefit for ETI. As a result of these findings, Los Angeles County paramedics now only perform BVM ventilation for pediatric OOHCA patients. The objective of our study was to compare survival-to-hospital discharge rates among adult nontraumatic OOHCA patients receiving airway management by ETI versus BVM.

## METHODS

### Study Design

This was an observational retrospective cohort study. The study was approved by the research committee and human subjects committee of our institution and met criteria for exception from informed consent.

### Study Setting and Population

The study site is a 553-bed general municipal hospital located in southwestern Los Angeles County, which has a population of approximately 11 million residents. The hospital catchment area is approximately 27 square miles. There are approximately 3,500 paramedics in Los Angeles County, and the county has ~330,000 advanced life support (ALS) and ~125,000 basic life support (BLS) runs per year; Harbor UCLA Medical Center receives roughly 2% of all ALS runs and 3% of BLS runs. The Los Angeles County emergency medical services (EMS) system is based on a two-tiered response activated by a central dispatch 9-1-1 network. First-responder engine units are manned by BLS Firefighter-EMT-1 personnel, at least one of whom on each unit is trained in the use of automated external defibrillators. Paramedics are certified ACLS providers and are trained in cardiac rhythm recognition, ETI, defibrillation, and pharmacologic interventions. When indicated, paramedics are trained to administer countershocks, administer CPR, perform intubation, establish intravenous access, and initiate pharmacologic therapy prior to base station contact. Additionally, since 2005, paramedics are allowed to pronounce cardiac arrest patients dead in the field when asystole is demonstrated in two leads. Subsequent interventions are under direct medical oversight via radio or phone by certified nurses or emergency medicine residents under emergency medicine faculty supervision. We included all consecutive adult (>18 years of age) out-of-hospital nontraumatic cardiac arrests presenting to the single municipal teaching hospital emergency department (ED) between November 1, 1994, and June 30, 2008.

### Study Protocol

Data were obtained from field rescue reports completed by paramedics, verbal reports from paramedics that are included in nursing and physician notes, the ED cardiac arrest flow sheet, the ED record, and in-hospital records for all patients who survived to hospital

admission. All data sources for each patient were abstracted by the investigators and entered into a database for later review. Data collection began on November 1, 1994, and extended to June 30, 2008; data were abstracted continually over the study period.

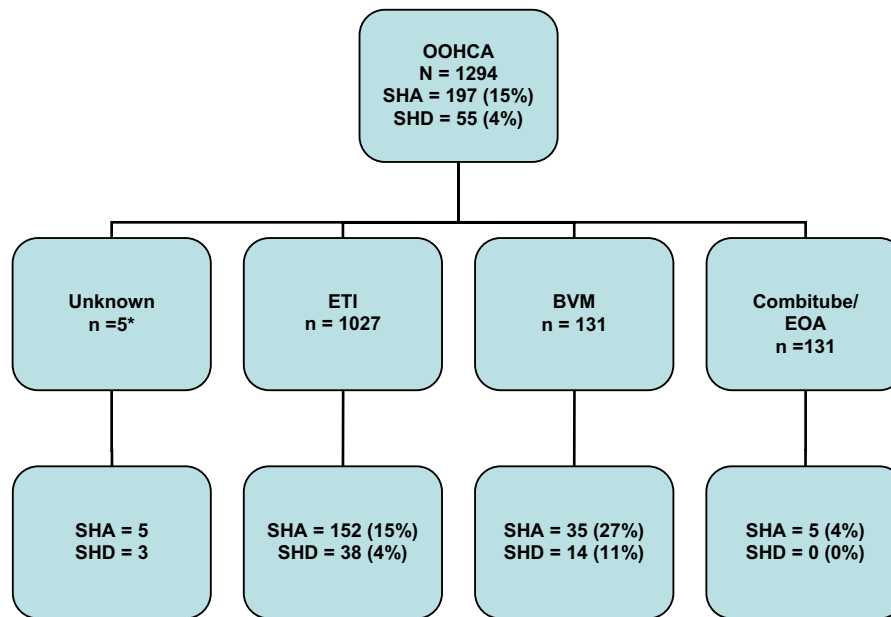
Two abstractors (JTN and MH) were trained to review and cull data from paramedic run sheets, nursing charts, and physician medical records. Neither abstractor was blinded to the hypothesis of the study. Exclusion criteria included “do not attempt resuscitation” status, age < 18 years, and cardiac arrest due to trauma, drowning, or drug overdose. The abstractors used a standardized form to record data, which included age, sex, race, any notable past medical history (e.g., congestive heart failure, renal failure, myocardial infarction, diabetes mellitus, hypertension), site of arrest (e.g., home, nursing home), rhythm upon paramedic arrival, whether it was a witnessed arrest, whether there was bystander CPR or return of spontaneous circulation (ROSC), the type of field airway implemented (endotracheal tube, esophageal obturator airway, Combitube, or BVM), survival to hospital admission, and survival to hospital discharge. Data sheets were randomly checked by the senior abstractor and questions about data entry fields or disagreements between abstractors were discussed until consensus was achieved.

### Data Analysis

Data were entered into a Microsoft Excel 2003 (Microsoft Corp., Redmond, WA) spreadsheet, and DBMS Copy was used to convert the file into an SAS v.9.2 (SAS Institute, Cary, NC) database. Descriptive statistics and odds ratios (ORs) were calculated to evaluate associations. A univariate OR was computed to describe the association between type of airway implemented and survival to hospital discharge. A multivariable logistic regression analysis was also performed to determine ORs for type of airway implemented and survival to hospital discharge, after adjusting for age, sex, site of arrest, rhythm on paramedic arrival, whether there was bystander CPR, and whether the arrest was witnessed. All ORs are reported with 95% confidence intervals (CI).

## RESULTS

A total of 1,294 nontraumatic cardiac arrests were reviewed. There were approximately equal numbers of subjects entered into the study each year. Figure 1 shows the subgroups with survival outcomes. The median age of the 1,294 subjects was 69 years with an interquartile range (IQR) of 57–79 years, and approximately 60% were male. Descriptions of demographic variables are shown in Table 1. Of the total 1,294 cases, only 55 patients (4.3%) survived to hospital discharge, whereas 197 (15.3%) survived to hospital admission. A total of 1,027 patients (79.4%) had an ETI placed in the field, whereas BVM ventilation was performed in 131 patients (10.1%), an esophageal obturator was placed in 29 (2.2%), and a Combitube was placed in 102 (7.9%). Five patients (0.4%) had incomplete prehospital records, and it was unclear what type of airway



**Figure 1.** Flow diagram with results of airway subgroup types. BVM = bag-valve-mask; EOA = esophageal obturator airway; ETI = endotracheal intubation; OOHCA = out-of-hospital cardiac arrest; SHA = survival to hospital admission; SHD = survival to hospital discharge. \*Patients with unknown airway management device were excluded in the first stage of the study and were not analyzed further.

Table 1  
Baseline Demographics of Subjects (n = 1,294)

| Variable                           | All Subjects | BVM        | ETI        |
|------------------------------------|--------------|------------|------------|
| Age, median years (IQR)            | 69 (57–79)   | 66 (56–77) | 71 (58–80) |
| Sex—male                           | 776 (60)     | 75 (57)    | 610 (59)   |
| Race                               |              |            |            |
| Asian                              | 203 (16)     | 20 (16)    | 167 (17)   |
| Black/African American             | 362 (28)     | 34 (27)    | 283 (29)   |
| White                              | 467 (36)     | 50 (40)    | 374 (38)   |
| Hispanic                           | 200 (15)     | 21 (17)    | 160 (16)   |
| Other                              | 12 (1)       | 0 (0)      | 9 (1)      |
| Unknown                            | 50 (4)       | 0 (0)      | 0 (0)      |
| Rhythm                             |              |            |            |
| Asystole                           | 569 (44)     | 50 (38)    | 455 (45)   |
| PEA                                | 357 (28)     | 56 (43)    | 266 (26)   |
| VF/VT                              | 360 (28)     | 25 (19)    | 300 (29)   |
| Site of arrest                     |              |            |            |
| Home                               | 778 (60)     | 70 (53)    | 615 (60)   |
| Nursing home                       | 325 (25)     | 40 (31)    | 270 (26)   |
| Other                              | 187 (15)     | 21 (16)    | 139 (14)   |
| Witnessed—yes                      | 750 (58)     | 93 (71)    | 581 (57)   |
| Bystander CPR—yes                  | 580 (45)     | 79 (61)    | 457 (45)   |
| ROSC—yes                           | 308 (24)     | 50 (38)    | 244 (24)   |
| ROSC location                      |              |            |            |
| Field                              | 101 (33)     | 12 (24)    | 87 (36)    |
| ED                                 | 207 (67)     | 34 (76)    | 157 (64)   |
| Airway                             |              |            |            |
| Bag valve mask                     | 131 (10)     | 131 (100)  | —          |
| Combitube                          | 102 (8)      | —          | —          |
| Esophageal obturator               | 29 (2)       | —          | —          |
| ETI                                | 1027 (80)    | —          | 1027 (100) |
| Survival to hospital admission—yes | 197 (15)     | 35 (27)    | 152 (15)   |
| Survival to hospital discharge—yes | 55 (4)       | 14 (11)    | 38 (4)     |

All values except age are n (%).

BVM = bag-valve-mask ventilation; CPR = cardiopulmonary resuscitation; ETI = endotracheal intubation; IQR = interquartile range; PEA = pulseless electrical activity; ROSC = return of spontaneous circulation; VF/VT = ventricular fibrillation/ventricular tachycardia.

Table 2  
Univariate and Multivariable Analysis for BVM/ETI for SHD

| Predictor Variable for SHD                 | Univariate OR (95% CI)       | Multivariable OR (95% CI)   |
|--|------------------------------|-----------------------------|
| BVM vs. ETI                                | 3.30 (1.8–6.3) $p = 0.0002$  | 4.5 (2.3–8.9) $p < 0.0001$  |
| VT/VF vs. all other rhythms                | 8.60 (2.7–27.9) $p < 0.0001$ | 9.3 (2.6–33.4) $p = 0.0006$ |
| Witnessed vs. unwitnessed                  | 4.10 (2.2–7.7) $p < 0.0001$  | 5.5 (2.8–11.1) $p < 0.0001$ |
| Bystander CPR vs. no bystander CPR         | 1.20 (0.7–2.0) $p = 0.6$     | 1.5 (0.8–2.7) $p = 0.2$     |
| Nursing home vs. all other sites of arrest | 0.40 (0.2–0.9) $p = 0.03$    | 0.4 (0.2–0.9) $p = 0.03$    |
| Male vs. female                            | 0.90 (0.6–1.6) $p = 0.9$     | 0.9 (0.5–1.6) $p = 0.7$     |
| Age  | 0.99 (0.97–1.00) $p = 0.3$   | 1.0 (0.98–1.02) $p = 0.9$   |

BVM/ETI = bag-valve-mask ventilation/endotracheal intubation; CPR = cardiopulmonary resuscitation; SHD = survival to hospital discharge; VF/VT = ventricular fibrillation/ventricular tachycardia.

management they had received. Three of these five patients survived to hospital discharge, whereas two survived to hospital admission only.

When comparing BVM versus ETI, the median age of the BVM group was 66 years (IQR = 56–77 years), whereas the median age of the ETI group was 71 years (IQR = 58–80 years). The unadjusted OR for BVM use and survival to hospital discharge, when compared to ETI, was 3.3 (95% CI = 1.8 to 6.3;  $p = 0.0002$ ). Multivariable logistic regression modeling to adjust for age, sex, site of arrest, rhythm on paramedic presentation, whether the arrest was witnessed, and whether there was bystander CPR demonstrated an effect estimate of 4.5 (95% CI = 2.3 to 8.9;  $p < 0.0001$ ; Table 2). Finally, we performed a sensitivity analysis in which we assumed that the three patients who had an unknown field airway status and survived to hospital discharge actually were endotracheally intubated, and there was no material difference in our effect estimates.

The unadjusted OR for bystander CPR and survival to hospital discharge, when compared to no bystander CPR, was 1.2 (95% CI = 0.7 to 2.0;  $p = 0.6$ ). Multivariable logistic regression modeling adjusting for age, sex, site of arrest, rhythm on paramedic presentation, whether the arrest was witnessed, and airway device demonstrated an effect estimate of 1.5 (95% CI = 0.8 to 2.7;  $p = 0.2$ ).

## DISCUSSION

Our study results demonstrate lower survival to hospital discharge rates among nontraumatic OOHCA patients undergoing ETI, when compared to those managed with BVM, even after adjusting for initial rhythm, whether there was bystander CPR, whether it was a witnessed arrest, age, sex, and site of arrest. More specifically, there was a fourfold greater OR for survival to hospital discharge for the BVM group when compared to ETI.

Studies demonstrate that a 50:2 compression-to-ventilation ratio<sup>15</sup> and continuous chest compressions<sup>16,17</sup> improve survival over traditional CPR among OOHCA patients. During cardiac arrest, chest compression is the major intervention that delivers blood flow to organs; compressions should not be interrupted for any other measures.<sup>18</sup> Ventilation-induced increases in intrathoracic pressures may impede venous return to

the heart, thereby decreasing forward blood flow to the myocardium and brain during CPR.<sup>19</sup> In multiple animal studies, chest compressions alone generate passive ventilation of the lungs,<sup>20–24</sup> and with adequate oxygen reserves in the body, passive ventilation may be enough to meet the oxygen demands of the body during cardiac arrest. Additionally, gasping has been shown to provide adequate oxygenation and is reported in 55% of patients with witnessed cardiac arrest.<sup>25</sup> The 2005 American Heart Association guidelines emphasize the critical importance of chest compressions and recommend that all rescue efforts, including insertion of an advanced airway, administration of medications, and reassessment of the patient, are performed in a way that minimizes interruption of compressions.<sup>18</sup>

Whether or not field ETI improves survival has been questioned in both the trauma literature<sup>1–10</sup> and non-trauma literature.<sup>11,12,14,26–29</sup> Only a few studies actually demonstrate a mortality or morbidity benefit of field ETI over other airway management options.<sup>30–32</sup> Rainer et al.<sup>26</sup> performed a prospective study of nontraumatic OOHCA patients comparing survival to hospital admission for paramedic ETI versus BVM and demonstrated a nonsignificant survival disadvantage for paramedic ETI. Pointer<sup>33</sup> reported an improved survival-to-hospital admission rate in patients who received ETI versus BVM in a study that retrospectively analyzed nontraumatic OOHCA patients; however, they did not account for any confounders. Unlike our study, neither of these studies reported survival to hospital discharge.

Adams et al.<sup>34</sup> reported decreased survival-to-hospital discharge rates for ETI compared to BVM among defibrillated nontraumatic OOHCA patients. However, there was again no adjustment for confounders, survival rates were lowest in patients with unwitnessed arrests, and these patients were also most frequently intubated. Holmberg et al.<sup>28</sup> also noted that intubation may be associated with decreased 1-month survival rates among over 10,000 OOHCA patients. Eckstein et al.<sup>10</sup> demonstrated a fivefold greater OR for hospital death among an ETI group versus BVM in 496 trauma patients. Similarly, Stockinger et al.<sup>1</sup> documented a higher mortality rate in trauma patients who received field ETI over BVM. Even when corrected for Injury Severity Score, Revised Trauma Score, and mechanism of injury, ETI was associated with mortality similar to or greater than BVM.



Our study demonstrated an overall survival to hospital discharge rate of 4%, which is comparable to rates Eckstein et al.<sup>35</sup> reported in Los Angeles County and those Nichol et al.<sup>36</sup> reported nationally. However, in contrast to other studies,<sup>37–39</sup> we did not observe a significant improvement in survival to hospital discharge for patients who received bystander CPR. Our paramedics only report if bystander CPR was performed but do not comment on the quality of the CPR. Although our bystander CPR rate of 45% is comparable to that of New York,<sup>40</sup> it is possible that Los Angeles County citizens are not as well trained and educated on appropriate CPR delivery. Many bystanders are reluctant to perform CPR due to the fear of delivering mouth-to-mouth ventilations; thus, implementing a compression-only CPR protocol may increase rates of bystander CPR.

## LIMITATIONS

Our study has many limitations, but the main limitation is due to its retrospective design. Because information was collected from paramedic run sheets, it was difficult to discern why BVM was used instead of ETI. Los Angeles County paramedics are not authorized to use neuromuscular blocking agents prior to intubation; thus, it is possible that patients who were intubated in the field were more severely ill (e.g., they were flaccid enough to be intubated without any pharmacologic agents). Moreover, our data were collected from one urban hospital system, and the generalizability of our results to rural areas where transport times are lengthy is unknown. Our data were collected over a long study period and we did not account for temporal effects or changes in resuscitation protocols over the years; however, survival to hospital discharge rates were similar on a yearly basis. We also assumed that all advanced airway adjuncts were properly positioned (e.g., endotracheal tubes were not mispositioned in the esophagus). Additionally, interrater agreement for the airway device recorded was not assessed for all run sheets. There is also the possibility for misclassification, because patients transferred to other facilities were classified as survivors, and these patients may not have survived to hospital discharge. Finally, since Glasgow Coma Scale scores were not available to us, we did not assess neurologic outcome, and it is possible that intubated patients had more favorable neurologic outcomes.

## CONCLUSIONS

In this cohort, when compared to bag-valve-mask ventilation, endotracheal intubation was associated with decreased survival to hospital discharge among adult nontraumatic out-of-hospital cardiac arrest patients. These results support the American Heart Association guidelines and the recent literature, which emphasize early cardiopulmonary resuscitation and defibrillation, rather than ventilation, to maximize survival outcomes in cardiac arrest patients.

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