The Safety, Efficacy, and Expediency of Albuterol Nebulizer Administration by BLS Providers

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Abbreviations:
ALS: Advanced Life Support
BLS: Basic Life Support
BVM: bag valve mask
COPD: chronic obstructive pulmonary disease
CPAP: continuous positive airway pressure
DSFS: Delaware State Fire School
ED: emergency department
EMS: Emergency Medical Services
EMT: emergency medical technician
HR: heart rate
OEMS: Office of Emergency Medical Services
RR: respiratory rate
spO2: pulse oximetry

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Abstract

Introduction: Many Emergency Medical Service (EMS) systems in the United States restrict albuterol therapy by scope of practice to Advanced Life Support (ALS). The State of Delaware has a two-tiered EMS system in which Basic Life Support (BLS) arrives on scene prior to ALS in the majority of respiratory distress calls.

Study Objective: This study sought to evaluate the safety, efficacy, and expedience of albuterol administration by BLS compared to ALS.

Methods: This retrospective observational study used data collected from July 2015 through January 2017 throughout a State BLS albuterol pilot program. Pilot BLS agencies participated in a training session on the indications and administration of albuterol, and were then authorized to carry and administer nebulized albuterol. Heart rate (HR), respiratory rate (RR), and pulse oximetry (spO2) were obtained before and after albuterol administration by BLS and ALS. The times from BLS arrival to the administration of albuterol by pilot BLS agencies versus ALS were compared. Study encounters required both BLS and ALS response. Data were analyzed using chi-square and t-test as appropriate.

Results: Three hundred eighty-eight (388) incidents were reviewed. One hundred eighty-five (185) patients received albuterol by BLS pilot agencies and 203 patients received albuterol by ALS. Of note, the population treated by ALS was significantly older than the population treated by BLS (61.9 versus 51.6 years; P <.001). A comparison of BLS arrival time to albuterol administration time showed significantly shorter times in the BLS pilot group compared to the ALS group (3.50 minutes versus 8.00 minutes, respectively; P <.001). After albuterol administration, BLS pilot patients showed improvements in HR (P <.01), RR (P <.01), and spO2 (P <.01). Alternately, ALS treatment patients showed improvement in spO2 (P <.01) but not RR (P = .17) or HR (P = 1.00). Review by ALS or hospital staff showed albuterol was indicated in 179 of 185 BLS patients and administered correctly in 100% of these patients.

Conclusion: Patients both received albuterol significantly sooner and showed superior improvements in vital signs when treated by BLS agencies carrying albuterol rather than by BLS agencies who required ALS arrival for albuterol. Two-tiered EMS systems should consider allowing BLS to carry and administer albuterol for safe, effective, and expedient treatment of respiratory distress patients amenable to albuterol therapy.

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Introduction

Thousands of people in the United States suffer from asthma and other bronchoconstrictive diseases or chronic obstructive pulmonary disease (COPD). Many patients require hospitalization and many more require emergent medical help, often calling for Emergency Medical Services (EMS) as the first line of their medical care. Notably, EMS personnel play a prominent role in triage, transport decisions, and initial management of patients with dyspnea, and evidence suggests that interventions in the prehospital setting can reduce mortality among patients with respiratory distress.[1]

One of the primary treatments for patients with asthma, COPD, and bronchospasm is the administration of albuterol. Earlier administration of albuterol is important in lessening the severity of respiratory distress caused by these disease processes.[2] While several prehospital studies have demonstrated patient improvement after treatment with beta-agonists for asthma,[3–6] many EMS systems restrict the use of albuterol to paramedics in the prehospital

setting. However, the availability of paramedics and other Advanced Life Support (ALS) personnel is limited in many areas, particularly in more rural environments. Emergency medical technicians (EMTs) or Basic Life Support (BLS) providers are more abundant and thus are often first to arrive on the scene. In such cases, the ability for EMTs to provide bronchodilators prior to ALS arrival may benefit a population of patients with dyspnea.

Multiple studies exist looking at respiratory distress and asthma in the prehospital setting. While some of these studies look at the safety profile of albuterol, they also address other factors such as a pediatric population or a more thorough asthma treatment pathway including steroids. Vonderohe, et al[7] demonstrated the safety and efficacy of albuterol 2.5mg via nebulizer. Historically, albuterol had only been administered by ALS, and as, such there is a paucity of the evidence as it relates to albuterol administration by BLS providers. The study State utilizes a two-tiered EMS system, in which BLS providers arrive separately on scene more often than ALS providers for respiratory distress calls.

Study Objective

The goal of this study was to assess the safety and effectiveness of a pilot protocol which allowed BLS providers in the State of Delaware to recognize bronchospasm and appropriately administer nebulized albuterol prior to arrival of ALS. It was hypothesized that albuterol would be both safe and effective in the hands of trained EMTs and could result in measurable improvements in vital signs such as respiratory rate (RR) and oxygen saturation. It was further hypothesized that patients could receive albuterol sooner and improve similarly if BLS was authorized to carry and administer albuterol in a two-tiered EMS system.

Methods

This was a retrospective observational study using data collected from July 2015 through January 2017 during the Delaware State BLS albuterol pilot program. The study was approved by the Christiana Care Health System (Newark, Delaware USA) Institutional Review Board, study reference CCC35058. The State of Delaware had a total population of approximately 990,000 and a total square mileage of 1,982 during the study period. The state comprises three counties with different population densities. A total of 72 prehospital BLS agencies exist throughout the State. Delaware BLS providers receive their state certification from the Delaware State Fire Prevention Commission (Kent County, Delaware USA) and most in-state training is provided by the Delaware State Fire School (DSFS; Kent County, Delaware USA). State EMS medical direction is provided by the Delaware Office of Emergency Medical Services (OEMS; Smyrna, Delaware USA) utilizing board-certified emergency medicine physicians.

In 2015, the Delaware OEMS and DSFS devised a pilot protocol to allow BLS to have standing orders to permit the administration of nebulized albuterol in certain respiratory distress cases. A total of 22 out of 72 State prehospital BLS agencies participated in the pilot protocol. Pilot BLS agency providers attended a three-hour training session on the indications and administration of albuterol, including lectures and skills-based learning. Following this training, participants were required to demonstrate proficiency and pass a written quiz before being authorized to carry and administer albuterol. These educational materials and assessments were developed and reviewed by the State OEMS and DSFS with training provided by the DSFS instructors.

The pilot protocol allowed participating BLS companies to carry and administer albuterol to patients with signs and symptoms of acute exacerbations of asthma, emphysema, reactive airway disease, or allergic reactions presenting with any combination of wheezing, cough, shortness of breath, diminished breath sounds, retractions, tachypnea, and/or air hunger. The BLS crews were instructed to follow appropriate airway and respiratory management, including initiation of supplemental oxygen, continuous positive airway pressure (CPAP), or bag valve mask (BVM) as indicated, and to contact ALS if not already dispatched. For alert patients not requiring BVM who met criteria for the pilot, albuterol via nebulizer was administered. The protocol was initiated by BLS only if they were on-scene prior to ALS arrival. For patients six years of age and older, albuterol 5mg was administered via nebulizer with oxygen flow set to eight liters per minute (LPM). For patients aged one-through-five, albuterol 2.5mg was administered via nebulizer with oxygen flow set to 8LPM. Medical control was to be contacted for adult patients with heart rate (HR) greater than 150 beats per minute (BPM) or pediatric patients with HR greater than 180BPM prior to initiation of albuterol. After the first albuterol dose, patients were reassessed including vital signs, lung sounds, and oxygen saturation. For persistent symptoms of respiratory distress, a second dose of albuterol was administered in the same dosing as the first. Although ALS was still indicated to assist with patient care, a BLS provider continuously monitored any patient for whom albuterol was initiated by BLS. The BLS providers were trained to recognize worsening respiratory failure or declining mental status despite albuterol and react accordingly by providing CPAP, BVM ventilation, or advanced airway management by ALS during transport.

Throughout the pilot study, crews were required to complete a data collection form devised by the Delaware OEMS for quality assurance review. In addition to demographic information, this form included documentation of the initial vital signs, including RR, pulse oximetry (spO2), HR, and blood pressure. The patient would then be re-evaluated following each albuterol administration, again with documentation of vital signs and any additional interventions with comments or complications. The providers also recorded if ALS was available on scene and any ALS interventions. The pilot form also contained information including the receiving hospital and a review by an advanced provider (physician, nurse, respiratory therapist, or paramedic) regarding the albuterol administration after independently evaluating the patient. The advanced practitioner review included whether albuterol was indicated, administered correctly, appropriately monitored, and whether respiratory status was appropriately managed with comment section. All albuterol data collection forms were reviewed by OEMS as part of Quality Assurance for the pilot program. The data forms for incidents in which albuterol was administered by BLS were collected and reviewed during the BLS pilot program and were compared to incidents in which ALS crews administered albuterol from a comparatively similar time. The study protocol compared vital signs before and after albuterol between BLS (pilot group) and ALS (control group) patients, as well as the time of BLS arrival to the time of albuterol administration by BLS or ALS providers. Data were analyzed using paired and independent sample t-tests, as well as chi-square, as appropriate.

Results

A total of 388 incidents of albuterol administration were reviewed during the study period. These incidents included 185 patients

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	BLS N = 185	ALS N = 203	P Value
Age (mean (min, max))	51.6 (3.0, 94.0)	61.9 (0.0, 97.0)	<.01
Gender, N (%)			
Male	70 (38.9)	92 (45.3)	.23
Female	110 (61.1)	110 (54.2)	
Other	0 (0.0)	1 (0.5)	
Race, N (%)			
Black	89 (51.1)	52 (28.3)	<.01
White	81 (46.6)	127 (69.0)	
Other	4 (2.3)	5 (2.7)	
Ethnicity, N (%)			
Hispanic/Latino	12 (8.2)	2 (1.4)	.01
Non-Hispanic/ Latino	134 (91.8)	137 (98.6)	

Table 1. Patient Population by EMS Provider Type

receiving albuterol administered by BLS providers and 203 receiving albuterol administered by ALS providers. There were significant differences in the mean age (P <.01), race (P <.01), and ethnicity (P = .01) among patients serviced by BLS and ALS providers (Table 1).

The BLS patients showed significant increases in spO2 (mean baseline spO2 = 89.99, mean change in spO2 = 7.72; 95% CI, 6.77 to 8.67; P <.01) after albuterol was administered. There were also significant decreases in HR and RR for patients treated by BLS providers (mean baseline HR = 105.24BPM, mean change in HR = -2.63BPM; 95% CI, -4.37 to -0.89; P <.01) and (mean baseline RR =27.03 breaths/minute, mean change in RR = -3.91 breaths/minute; 95% CI, -4.68 to -3.14; P <.01), respectively.

The ALS providers demonstrated favorable results during the study period, but these findings were only significant for spO2 (mean baseline spO2 = 90.8%, mean change in sp02 = 3.83; 95% CI, 1.81 to 5.84; P <.01). Significant differences in the vital signs of patients treated by ALS providers were not seen for RR or HR (mean baseline RR = 26.87 breaths/minute, mean change in RR = -0.87 breaths/minute; 95% CI, -2.11 to 0.37; P = .17) and (mean baseline HR = 101.62BPM, mean change in HR = 0.1BPM; 95% CI, -2.37 to 2.38; P = 1.00), respectively (Table 2).

A comparison of BLS arrival time to albuterol administration time showed significantly shorter times in the BLS pilot group compared to the ALS group (3.50 minutes, IQR: 2-5 minutes versus 8.00 minutes, IQR: 5-13 minutes), respectively (P <.001).

Lastly, review by ALS or hospital staff showed albuterol was indicated in 179 of 185 (96.8%) of BLS patients and administered correctly in 100% of these patients.

Discussion

Respiratory distress continues to be a major source of morbidity and mortality in the United States. There is a need to provide care for patients with dyspnea prior to arriving at an emergency department (ED), the burden of which falls largely on EMS providers. Albuterol has been shown to be a safe and effective first-line treatment for bronchospasm, leading to improvement in patient condition, and thus becoming the primary initial therapy for most asthma exacerbations.[2]

Albuterol is generally considered a safe and effective first-line therapy. However, albuterol administration is not without adverse effects and risks do exist. The US Food and Drug Administration (FDA; Silver Spring, Maryland USA) lists albuterol side effects including tachycardia, hypokalemia, and changes in blood glucose. It is also important to ensure that albuterol is being given to the correct population. All EMS providers must receive training prior to carrying and administering albuterol to patients. Additionally, patients receiving albuterol may still deteriorate after administration and could require additional therapies including advanced airway methods or steroids. As such, all BLS agencies who participated in this albuterol study had been previously trained and authorized to utilize CPAP as needed, which had been shown safe and effective for use by BLS providers.[8] Albuterol therapy should not be used in lieu of further BLS or ALS interventions and the intent of this study was not to replace ALS intervention or discontinue an ALS response in a two-tiered system. This study shows that trained BLS providers in the State of Delaware successfully and appropriately administered albuterol in the field when ALS providers were not immediately available. Patients received albuterol significantly sooner when treated by BLS agencies carrying albuterol rather than by BLS agencies who required ALS arrival for albuterol. This resulted in improvement in patient condition, as shown by increase in spO2 and decrease in RR. Other studies assessing urban EMS systems have found similar results,[2,9] although the study by Abarbanell, et al[2] targeted EMT-Intermediate/EMT-Advanced providers which are not recognized in all EMS systems. The BLS agencies who participated in this study served various population density districts, including urban and rural, making these findings relevant to most EMS environments throughout the country. These geographic differences translate to different systems of care.[10] Utilizing BLS providers for the administration of albuterol could be particularly important in rural areas where ALS providers are less abundant.

Previous studies have shown a low percentage of albuterol administration for patients with asthma in the prehospital setting.[11] One thought to improve the availability of advanced medications, such as albuterol, is to increase the number of ALS providers. However, in many systems, this is not an option due to budget constraints or physical availability of ALS providers. By expanding the scope of practice for BLS providers, more patients may have access to life-saving medications prior to ED evaluation. Albuterol is generally administered by inhalation, either nebulized or via metered dose inhaler. These modalities are safe, non-invasive, and can be administered quickly with minimal set-up. Since the completion of this study, the National Highway Traffic Safety Administration (NHTSA; Washington, DC USA) included the use of inhaled beta agonist/bronchodilator and anticholinergic agents for dyspnea and wheezing by EMTs with medial director approval.[12] Hopefully this study will further support the use of albuterol by BLS providers as previously shown,[9,13] while also demonstrating the benefit of timely administration of albuterol by BLS in a two-tiered EMS system.

Of note, after completion and review of the pilot program data, utilization of nebulized albuterol has been adopted into the BLS standing orders in Delaware with over 2,900 administrations in the three years following the pilot. There were no serious adverse events or sentinel events noted during on-going quality assurance.

Limitations

It was unclear the final diagnosis at the hospital given to the patients enrolled in this study. Patients were confirmed to have received the medication appropriately as evaluated by a higher-level

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	BLS			P Value	ALS			P Value
	Before Mean (SD)	After Mean (SD)	Mean Difference (95% CI)		Before Mean (SD)	After Mean (SD)	Mean Difference (95% CI)	
Respiratory Rate	27.03 (SD = 7.52)	22.90 (SD = 6.37)	-3.91 (-4.68 to -3.14)	<.01	26.87 (SD = 8.17)	26.15 (SD = 8.46)	-0.87 (-2.11 to 0.37)	.17
Pulse Oximetry	89.99 (SD = 6.19)	97.63 (SD = 2.80)	7.72 (6.77 to 8.67)	<.01	90.8 (SD = 10.73)	94.64 (SD = 9.28)	3.83 (1.81 to 5.84)	<.01
Heart Rate	105.24 (SD = 17.73)	103.39 (SD = 18.97)	-2.63 (-4.37 to -0.89)	<.01	101.62 (SD = 23.24)	101.45 (SD = 24.37)	0.10 (-2.37 to 2.38)	1.00

Table 2. Vital Signs Before and After Albuterol Administration by EMS Provider Type

provider. This evaluation included a range of providers among physicians, nurses, respiratory therapists, and paramedics.

The patient populations were statistically different. These differences include race and the older population in the ALS group. It is unclear why these differences occurred or how many of the patients in the ALS group could have received albuterol by the EMTs and did not. Further study would be beneficial to understand why these differences may have existed, such as increased difficulty with identifying reactive airway disease or bronchospasm in an older population.

Finally, patient vital signs were recorded before and after the first dose of albuterol. This consisted of a single dose of 5mg nebulized albuterol. Patients most likely received more albuterol, however uniform assessment of patient response was not part of the study protocol.

Conclusion

Administration of nebulized albuterol by BLS providers is safe and effective when treating patients suffering from exacerbations of bronchoconstrictive diseases, COPD, or bronchospasm. Two-tiered EMS systems should consider allowing BLS to carry and administer albuterol for more expedient treatment of respiratory distress patients amenable to albuterol therapy. The administration of albuterol by BLS should also be considered by EMS agencies who service rural or under-served areas where BLS resources may be more available than ALS resources.

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