American Journal of Emergency Medicine xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Comparison of bronchodilator administration with vibrating mesh nebulizer and standard jet nebulizer in the emergency department

Robert B. Dunne, MD, FACEP, FAEMS, Vice Chair of Emergency Medicine, Associate Professor [a,b,*], Sandra Shortt, RRT [c]

[a] Department of Emergency Medicine, St. John Hospital and Medical Center, United States
[b] Wayne State University, School of Medicine, Detroit, MI 48236, United States
[c] Respiratory Care, St. John Hospital and Medical Center, Detroit, MI 48236, United States

ARTICLE INFO

Article history:
Received 20 July 2017
Received in revised form 30 October 2017
Accepted 30 October 2017
Available online xxxx

Keywords:
Vibrating mesh
Adapter
Aerosol
Jet nebulizer
Mesh

ABSTRACT

Introduction: Projects comparing bronchodilator response by aerosol devices in the ED are limited. Evidence suggests that the vibrating mesh nebulizer (VMN) provides 5-fold greater aerosol delivery to the lung as compared to a jet nebulizer (JN). The aim of this project was to evaluate a new nebulizer deployed in an Emergency Department.
Methods: A quality improvement evaluation using a prospectively identified data set from the electronic medical record comparing all ED patients receiving aerosolized bronchodilators with the JN during September 2015 to those receiving aerosolized bronchodilators with the VMN during October 2015.
Results: 1594 records were extracted, 879 patients received bronchodilators via JN and 715 patients via the VMN. Admission rates in the VMN group were 28.1% and in the JN group at 41.4%. The total albuterol dose administered was significantly lower in the VMN group compared to the JN ($p < 0.001$). No patient in the VMN group required >5 mg albuterol to control symptoms (85% of the VMN group received only 2.5 mg) whereas dosing in the JN group was higher in some patients (with 47% receiving only 2.5 mg). The use of VMN was also associated with a 13% (37 min) reduction in median length of stay in the ED.
Conclusions: The VMN was associated with fewer admissions to the hospital, shorter length of stay in the ED and a reduction in albuterol dose. The device type was a predictor of discharge, disposition and amount of drug used. Randomized controlled studies are needed to corroborate these findings.

1. Introduction

Asthma and chronic obstructive pulmonary disease (COPD) are among the top twenty diagnoses associated with ED visits with albuterol being one of the most commonly administered medications and nebulizer therapy accounting for approximately 4 million ED procedures annually in the US [2].

Historically, inhaled bronchodilators have been administered with jet nebulizers (JN) ranging in lung delivery efficiency of between 5 and 12% inhaled dose [3,4,6]. Advancements in aerosol delivery devices have improved aerosol delivery to the lung. The vibrating mesh nebulizer with the valve-adapter (VMN) (Aerogen Solo with Ultra, Aerogen Ltd., Ireland) has been reported in simulated breathing models to provide greater aerosol inhaled mass with 2 L/min oxygen flow via mouthpiece (VMN; 15.42 ± 1.4%) compared to a JN with 2 L/min oxygen flow (7.7 ± 0.62%) [5].

Scintigraphy data also demonstrates greater drug delivery efficiency. In a crossover-study of 6 healthy adults comparing radio-tagged aerosol deposition using VMN (Aerogen Solo with Ultra, Aerogen, Galway, Ireland) and JN, the VMN resulted in 5-fold greater aerosol delivered to the lungs than JN, expressed as a percentage of the nominal dose of radio-tagged solution placed in the device (22.8% ± 9.83, 4.5% ± 1.35), respectively [1].

Based on these studies demonstrating greater efficiency of drug delivery, we expected that a higher dose of bronchodilator would be delivered in patients with acute respiratory distress with the VMN [1,5,7]. This project was designed to help evaluate a new nebulizer that the hospital was considering expanding the use of. Often hospital equipment choices have little input from the clinicians. The hospital had been using vibrating mesh nebulizers on the ventilators for many years and was evaluating a change in the nebulizers used for acute care. The aim

* Corresponding author.
E-mail address: rkdunne@wayne.edu (R.B. Dunne).

https://doi.org/10.1016/j.ajem.2017.10.067

of the project was to determine whether the type of bronchodilator delivery device would have an effect on any patient related factors.

2. Methods

This was a quality improvement project assessing the introduction of a new nebulizer into the Emergency Department. The VMN was substituted for JN for an evaluation period of 30 days for all patients receiving inhaled bronchodilator therapy in the ED. This project was reviewed by the IRB waiving as an exempt quality assurance project.

Respiratory therapy (RT) staff were trained in the use of the hand held VMN. The RT was responsible for administering all aerosol treatments and recording the data in the patient EMR (Cerner, Firstnet™) per hospital protocol.

Prior to initiation of the project, a data set from Cerner, Firstnet™, was identified for the evaluation of the device. At the completion of the 30-day period, the predetermined data set which included age, disposition, chief complaint, total amount of albuterol delivered, final diagnosis and length of stay in the ED, was retrieved from the clinical EMR of all ED patients receiving aerosol bronchodilator treatments with the standard of practice JN in September 2015 and with the VMN in October 2015. Only the prospectively identified data set was utilized for evaluation, there was no ad-hoc retrospective chart review. This data extraction plan was designed to reduce bias inherent to many projects that use existing data. The population included all patients (adult and pediatric) who presented to the ED and received bronchodilator aerosol therapy. Protected Health Information (PHI) was not included in the data extracted.

2.1. Nebulizers utilized

A jet nebulizer (JN; VixOne, Westmed, Inc., Tucson, AZ) and a vibrating mesh nebulizer with a valved-adapter (VMN; Aerogen Solo with Ultra, Aerogen Ltd., Galway, Ireland) were the two devices compared. The JN was operated with oxygen from a 50-psi source at 8 L/min with a mouthpiece or an aerosol mask. Selection of mask or mouthpiece was RT driven and based upon the ability of the patient to co-ordinate a proper mouthpiece treatment.

For patients using VMN and the valved-adapter, a mouthpiece treatment with no added flow was the method of choice, with an option for use of a valved-mask for those patients who were too young or unable to coordinate a mouthpiece treatment. Minimal added oxygen flow was used with the valved-mask as per device label (pediatric; minimum/maximum flow 1 L/min/2 L/min, adult; minimum/maximum flow 2 L/min/6 L/min).

2.2. Medication

Patients admitted to the ED were administered an initial dose of albuterol sulfate (0.083% 2.5 mg/3 mL solution) as prescribed by the attending ED physician. The dose was titrated up based on physician order. Patients were only administered the higher doses if felt to be clinically indicated by the treating physician.

2.3. Statistical analysis

Statistical analysis included descriptive statistics, regression testing, Pearson chi square tests of independence and Mann-Whitney analysis. ($p < 0.05$) was considered significant using SPSS v22, IBM, Chicago, IL. Multinomial logistic regression was used to predict the effect the device would have on disposition, controlling for both diagnosis and age. Pearson chi-square test of independence was used between group and total albuterol dose (z-proportion tests comparing column proportions) to compare the populations, which were not normally distributed for total dose. The Mann-Whitney test was used to compare median LOS in the ED for each device.

3. Results

A total of 1594 patient consecutive encounters were extracted (879 JN and 715 VMN). Statistical review of populations showed similar demographic characteristics across both groups (Table 1) although the mean age was slightly lower in the VMN group. Patient disposition data are presented in Table 2. Admission rate for the VMN group was 32% lower (a 13.3 percentage point difference) than the JN group admission rate (Fig. 1), coinciding with a JN discharge rate that was 30% higher (a 13.1 percentage point difference) compared to the VMN discharge rate (Fig. 2). Furthermore, the total albuterol dose administered was significantly lower in the VMN group ($p < 0.001$) (Table 3). No patient in the VMN group required >5 mg albuterol to control symptoms (85% of the VMN group received only 2.5 mg) (Fig. 3). A small number of patients in the JN group (<1%) required a continuous infusion of inhaled albuterol to control their symptoms (400 mg of albuterol in an infusion bag prepared and issued by pharmacy and connected to a JN and titrated until symptomatic relief). Unfortunately, for these patients the portion of the total dose delivered was not recorded in the EMR and these patients were excluded as outliers from the analysis in Table 3.

Controlling for age and diagnosis, the VMN group was 1.5 times more likely to be discharged than the JN group (OR = 1.5, $p < 0.001$), respectively) and the JN group was 1.7 times more likely to be admitted than the VMN group (OR = 1.77, $p < 0.001$). (Table 4). Patients older than 19 treated with the VMN had significantly lower admission rates; patients younger than 19 years of age showed no significant difference in admission rates (Table 2, Fig. 4). A breakdown of the patients 65 years and older showed a 76% admission rate for the JN group as compared to a 61% admission rate for the VMN group (Fig. 6). The reduction of admission rates associated with the VMN in the 65 years and older group was 15.5% (−0.154912 to be exact) with a 95% confidence interval of 4.5% to 26.5% and a (p-value = 0.006).

The median length of stay in the ED was 37 min shorter (13% reduction) with the VMN group (4 h and 10 min) than with the JN group (4 h 47 min; ($p = 0.0001$) (Fig. 5). Length of stay was defined by electronic health record time points, specifically the initial quick registration time to the time of discharge from the emergency department.

Heart rate post treatment decreased in the JN group and increased post treatment in the VMN group. There was no difference in respiratory rates pre and post treatment in the JN or VMN group. (Table 5).

4. Discussion

Patients in acute respiratory distress from reversible bronchoconstriction remain a serious challenge in the emergency medicine setting. The recent development of VMN technology has been well received in the ICU setting with widespread use, but little has been documented regarding potential impact of such technology in the emergency department.

Prior to our project no clinical outcome comparisons between VMN and JN had been reported. However, scintigraphy data had suggested greater efficiency of drug delivery associated with the VMN as compared to JN [1,7].

Table 1
Baseline demographics of patients who received either JN or VMN nebulization.

	JN	VMN	*P* value
N	879	715	
Gender			0.337
Female sex No. (%)	(51.8)	(54)	
Male sex No. (%)	(48.2)	(46)	
Age (mean(SD))	42.23 (25.75)	36.86 (25.04)	<0.001
Pre Heart Rate (mean (SD))	102.43 (26.60)	100.37 (25.60)	<0.001
Pre Respiratory Rate (mean (SD))	19.25 (6.30)	22.88 (6.51)	<0.001

Pearson Chi-square and independent sample-*t*-test.

Please cite this article as: Dunne RB, Shortt S, Comparison of bronchodilator administration with vibrating mesh nebulizer and standard jet nebulizer in the emergency department, American Journal of Emergency Medicine (2017), https://doi.org/10.1016/j.ajem.2017.10.067