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A Survey on Method of Aerosol Therapy in Patients on Invasive Mechanical Ventilation in Intensive Care Unit and its Impact on Drug Delivery

Dr Sanjeev Kumar Singla

Assistant professor, Department of Anaesthesia and Intensive care, Adesh medical College and hospital, Bathinda, Punjab(India)

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Abstract: Background; Aerosol therapy is a common intervention done on mechanically ventilated patients in intensive care unit all over the world. The agents used by this route include bronchodilators, anti-inflammatory, antibiotics, mucolytics, prostacyclins etc.
Objective; The position of nebulizer device is very important for effective drug delivery, so we decided to conduct this study.
Method; This is a prospective observation study conducted on adult patients over a period of 6 months who were on invasive mechanical ventilation and nebulization therapy in intensive care unit of a tertiary health care hospital.
Results; 160 patients were on nebulization therapy, 100 patients were male and 60 female.146 patients were having endotracheal tube insitu and 14 patients were having tracheotomy tube insitu. Total nebulization events were 9840. 69.20% of the patients were nebulized in ideal way, rest were in a inefficient way.
Conclusion; Given the challenges of effective aerosol treatment of the critically ill patient on invasive mechanical ventilation, cost of treatment and better patient outcome, it is necessary to optimize as many factors as possible for effective drug delivery. Hence, guidelines for effective aerosol therapy should be developed and appropriate training and education of the nursing staff is of utmost importance.

Keywords; Nebulizer, Ventilator circuit, Invasive ventilation, Intensive care unit

INTRODUCTION

Aerosol therapy with various agents is commonly used for various lung pathologies in intensive care unit all over the world. The agents used by this route include bronchodilators, anti-inflammatory, antibiotics, mucolytics, prostacyclins etc. Nebulizer devices used in intensive care unit are categorized as nebulizers and metered dose inhalers (pMDIs). Nebulizers used can be divided into three categories: jet, ultrasonic, and mesh. Jet nebulizers are based on the Venturi and Bernoulli's principle, changes liquid form into aerosols that are inhaled by patients into the pulmonary system. [1]During nebulizationtherapy, the temperature of liquid in nebulizer device decreases with time and becomes concentrated because of evaporative loss within the nebulizer. The particle output and droplet size vary in proportion to the temperature of the liquid.[2,3]Ultrasonic nebulizers use ultrasonic waves that pass through the liquid in the nebulizer device and generate particles at the surface of the liquid. Mesh nebulizers are better than other types of nebulizers. They are more efficient and with significant advantages. Compared with jet nebulizers, vibrating mesh nebulizer (VMNs) increase the aerosol delivery by 2–4 times[4],most efficient particles size for therapeutic purposes is between 2–5 μm andthe main mechanism for pulmonary deposition is by diffusion. The best technique of aerosol therapy is important to deposit the drug to the distal airways. The drugs are delivered at site of action directly; require low dose and thus fewer systemic side effects. The desired effect is seen rapidly. However, correct inhaler technique should be followed in order to improve drug delivery. The success of delivery of nebulized medications to the invasively ventilated patients depends upon the type of nebulizer device, the position of device during therapy and the efficiency of devices. As aerosol therapy is an important treatment part in patients on invasive mechanical ventilation, even with most efficient methods only 35-40% of the drug reaches the lower airways, thus the technique of aerosol therapy is very important in critical care, so we decided to conduct this study.

OBJECTIVE

Various positions of nebulizer device used by nursing staff for aerosol delivery in patients on invasive mechanical ventilation in intensive care unit and its impact on drug delivery.

METHODOLOGY

This is a prospective observational study that was conducted in intensive care unit in a tertiary care centre of north India over a period of 6 months. The adult patients of age greater than 18 years who were on invasive mechanical ventilation and aerosol therapy were included in the study. The pediatric patients and patients who were not on any nebulization were excluded from the study. The data regarding where the aerosol device was attached in the ventilator circuit in each of the shift by nursing staff was collected and analyzed by descriptive analysis method.The various positions of nebulizer devices are shown in figures (1-6).

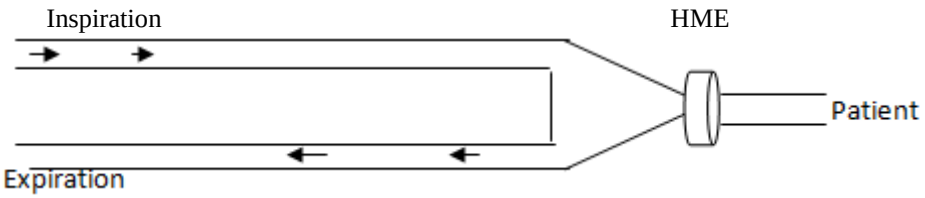

Figure 1 Normal ventilator circuit

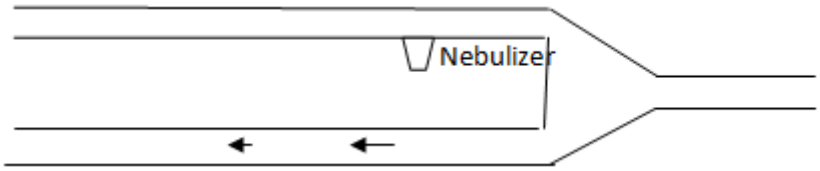

Figure 2-nebulizer on inspiratory limb 15 cm proximal to y piece without HME ideal position

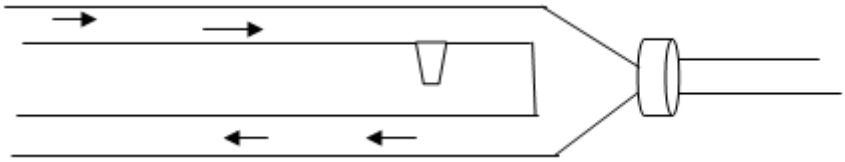

Figure 3- nebulizer on inspiratory limb 15 cm proximal to y piece with HME

Figure 4- Nebulizer with HME close to patient

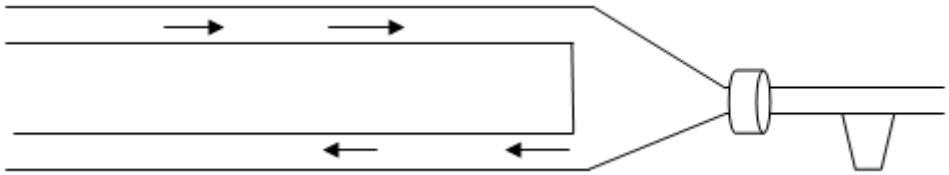

Figure 5- Nebulizer with HME distal to patient

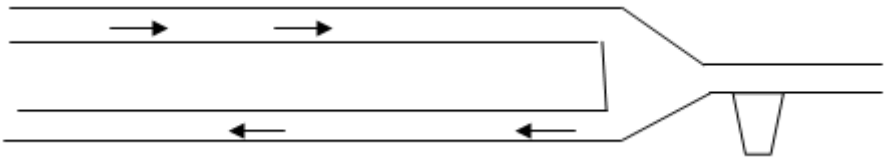

Figure 6- Nebulizer in common limb

RESULTS

The total number of patients who were on invasive mechanical ventilation was 190.The results were as per (Table 1). 160 patients were on nebulization therapy, 100 patients were male and 60 female.146 patients were having endotracheal tube insitu and 14 patients were having tracheotomy tube insitu.Total nebulization events were 9840.69.20% of the patients were nebulized in the ideal way, rest were in an inefficient way.

Characteristic	Male N(%)	Female N(%)	Total N(%)
Invasive Ventilation and on nebulization	100(62.5)	60(37.5)	160
ETT	92(57.5)	54(33.75)	146(91.25)
Tracheotomy	8(5.0)	6(3.75)	14(8.75)
Nebulization	6620(67.28)	3220(32.82)	9840
Figure 2	4470(45.42)	2340(23.78)	6810(69.20)
Figure 3	600(6.1)	230(2.33)	830(8.43)
Figure 4	*270(2.74)*	150(2.47)	420(4.27)
Figure 5	110(1.12)	45(0.45)	155(1.57)
Figure 6	1170(11.90)	455(4.63)	1625(16.53)

DISCUSSION

Aerosol therapy is most common intervention in critical care unit. We studied the common position of nebulizer position in ventilator circuit. Around 70% of all nebulizations were given in ideal recommended position, rest all were in compromised position and thus was not effective. The ideal position is shown in Figure 2, in this position the aerosol is concentrated in the side of the ventilator circuit that is used for inspiration, thus during inspiration the concentrated air with nebulized drug is delivered to the patient.[5]In Figure 3 position the drug delivery is hampered by HME. In rest of the positions the aerosol drug is lost in expiratory limb. During mechanical ventilation heat and humidity is retained by Heat-and-moisture exchangers (HMEs) used in the ventilator circuit. Because the filter in the HME blocks aerosol delivery and HME can get blocked, thus HMEs should be removed from the ventilator circuit during aerosol therapy.

Nebulization therapy is used for effective drug delivery to invasively ventilated patients. The MDI and nebulizers produce particles in the range of 1–5 µm.[6]MDI device used with spacer, the delivery of aerosol at the distal end of the Endotracheal tube(ETT) has a particle size of approximately 2µm. Likewise, nebulizers that produce aerosols in this range, are more efficient for aerosol delivery during invasive ventilation than the devices that produce particles of larger size.[7,8,9,10]The particle size is a important factor in aerosol deposition in critical patients. As the particle size produced by aerosol device increases, the particles get trapped in the ventilator circuit and artificial airways. The concentration of drug delivered past artificial airways is decreased. With jet nebulizer use flow 6-8l/min, add 2-3 ml saline solution, attach nebulizer device 15 cm proximal to y piece on inspiratory limb. Cost of treatment is a major factor in device selection, a device that is costly, is less likely to be used. Other factors that are important in aerosol deposition in the lower airways include physical and chemical properties of drug used, the type of the device, the position of the nebulizer device in the ventilator circuit, ventilator settings, heating and humidification of the inhaled air, the anatomy of the airways, the characteristics of the endotracheal tube,the presence of airway secretions and the anatomy of the airways. [11,12]About 95 % of intensivists routinely prescribe aerosol medications. One of thereports showed that there was lack of scientific knowledge of nebulization therapy and emphasized on education, research and training in this area.[13]

CONCLUSION

The drugs commonly used for nebulization are bronchodilators, anti-infective agents such as tobramycin, colistin and anti-inflammatory agents like steroids. The effective aerosol treatment of the critically ill on invasive mechanical ventilation is a challenge.For better patient outcome and effective drug deliver, the various factors affecting nebulizer therapy are needed to be optimized. The guidelines for effective aerosol therapy should be developed and appropriate training and education of the nursing staff is of utmost importance.

Conflict of Interest – None
Financial Support – None

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