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Nebulizers: A Review Paper

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Abstract: Nebulization or atomization is a technique of transforming liquid into a fine mist and the machine used for this particular purpose is called a nebulizer. Generally nebulizers can be sorted into jet, ultrasound and mesh which are classified on the basis of the method of production of aerosols from liquid. Various factors such as distal drug deposition on the face and mask, median aerodynamic diameter, remaining drug after nebulizing and nebulization time, determine the extent of performance and its efficiency. All the three kinds of nebulizers have different properties this paper will focus on the nebulizer types, their performance and uses in the medical field.

Keyword: Nebulization, atomization, ultrasound, nebulizer,performance

I. INTRODUCTION

Nebulizers are medical devices that convert liquid drug into aerosols or fine mist of minimal size whichcan be easily inhaled so that it directly reaches the inferior part of the respiratory tract, through a facemask or mouth piece. A nebulizer can be used with an electrical compressor, which vaporizes drugs so that they can be inhaled to open out the airways, or it can use an ultrasound crystal that vibrates. Mesh nebulizers use a new type of technology which forces liquid medications through a mesh, which has multiple apertures, in order to generate fine mist or aerosol. Following factors affect the deposition of drug to the patient:

- Nebulizer that is being used,
- Patient and nebulizer interface, and
- Rate at which the patient breathes [1].

The time required to nebulize the ordered dose of a common bronchodilator such as albuterol (used for asthma, emphysema and other lung conditions) varies from nebulizers of specific brand and rate of flow of dose from the source of gas supply (i.e. compressed air/gas).An efficient nebulizing machine is required to supply the dose in about six minutes[2]. There are certain techniques by which the performance of a nebulizer can be determined. These include:

- An analysis by weighing nebulizers before and after nebulization.
- Volumetric analysis.
- Measuring particle size distribution.
- After filtration, the drug that is inhaled is adjusted with the help of vivo radionuclide lung scanning or infrared photospectrometry [3].

II. TYPES OF CHARACTERISTICS

Nebulizers can be characterized as:

A. Jet Nebulizer

Venturi effect is the working principle of these nebulizers, according to which the pressure of fluid reduces and as the drug passes via narrow cross-sectional area. There are some main problems faced with jet nebulizers that there is a requirement of extra tubing as well as the compressed gas, generation of noise during their operation and the problem with the temperature drop of the medication in the storage space which is mainly because of the evaporation of liquid to form droplets of nebulized drug [4- 6].

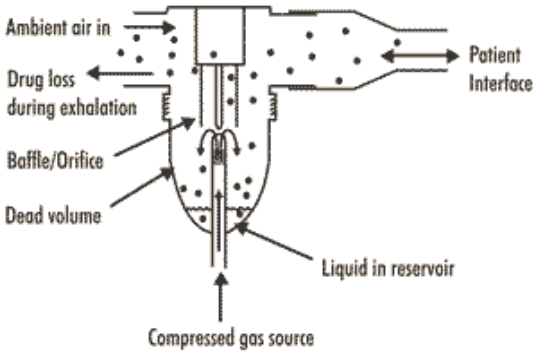

Figure 1: Jet Nebulizer [27]

Jet nebulizers can be distinguished into three separate models, breath-actuated, breath-enhanced and constant output. Best performance is provided by BAN that is Breath-actuated nebulizers as, they produce aerosol when the patient inspires, thereby reducing the wastage of medicine [7-12]. Breath-enhanced type helps the patient to inspire more air along with the normal dosage of medication and also it has an additional feature (called continuous nebulization) of recycling the drug in the medication camber itself when the patient is not inhaling [13].

B. Ultrasonic Nebulizers

In these types of nebulizers, ultrasound waves forming vibrations of high frequencies that are responsible to break the liquid into smaller droplets. Compared to previously discussed type of nebulizer, these nebulizers are more costly and these nebulizers tend to make the liquid medication warmer. In ultrasonic nebulizers, the force which atomizes the liquid drug is reduced because of which they operate less efficiently as compared to jet nebulizers[14, 15].

C. ***Mesh*** **Nebulizers**

Mesh nebulizers usemicropump technology through which aerosol is produced. The liquid medication is forced through multiple apertures in a mesh form so as to generate the aerosol. As compared to other two type of the nebulizers these are small and portable that can be operated via batteries or electricity, noise free operation, treatment times are shorter, greater output efficiency and minimal residual volume. Major advantages of these nebulizers are their ability to nebulize the liquid drug in low volumes drug volume. [14, 16-19].

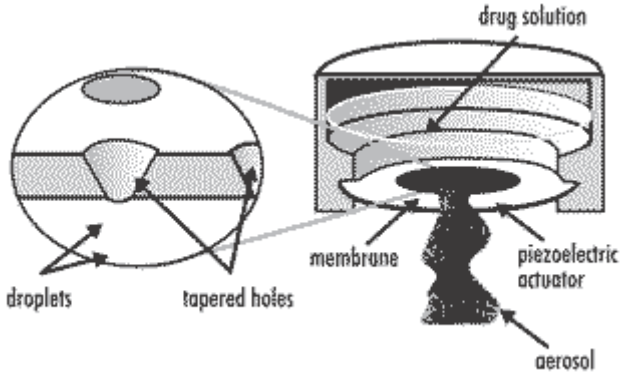

Figure 2: Ultrasonic Nebulizer (27)

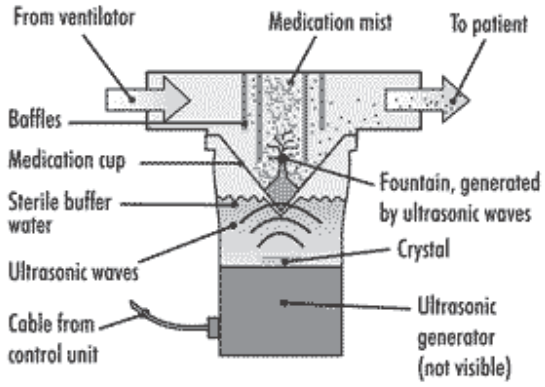

Figure 3: Mesh Nebulizer [27]

D. **Characteristics of Nebulizer Performance**

There are some important characteristics like the respirable dose that is provided to the patient that determines the performance of the nebulizers and, total mass in output and the size of the aerosol droplet (around 2 to 5 nm for air accumulation and 1 to 2 nm for parenchymal accumulation) determines the amount of drug that can be inhaled by the patient [20].

There are some other important characteristics that describes the performance of the machine that comprises of time taken to nebulize a required mount of drug, price, usage convenience and necessity for disinfecting after use. Time taken by the nebulizer to deliver certain amount of drug is a crucial factor that plays an important role for the patient compliance. Generally, a short nebulization time is desirable as it proves to be more effective. Most of the nebulizers that are available are less expensive, produced in bulk and are for single patient use only. Therefore, the outcome also varies in their performances [2, 21-23].

Nebulizer's performance also depends on some technical factors and varies from one manufacturer to another. Single-patient use nebulizers are typically used because they are cost effective and disposable which serves as an advantage for the treatment of outpatients as well as the patients that are hospitalized. [24].

There are several factors that affect the performance of the nebulizers depending on the breathing pattern of the patients that affects the quantity of medicine to be delivered tothe inferior part of the respiratory tract. The patient is advised to perform a slow and deep breathing pattern so as to allow aerosol to penetrate more and effectively get deposited in the lungs of the patient. [25].

III. TECHNOLOGICAL ADVANCEMENTS

- No drug is wasted in case of breath-actuated nebulizers (BAN) as aerosolized droplets are emitted when the patient inhales through the face mask, so no amount of medicine iswasted and there is no escaping of toxic or expensive drugs to the surrounding environment.
- Vibrating mesh technology is also a new innovation. Machines such as ParieFlowand Omron U22 that have a mesh like structure (plate) through which the liquid drug broken into fine mist as it vibrates due to the presence of a piezoelectric crystal [5].
- Software control is being coupled with nebulizer as in AKITA systems. It contains a normal jet or mesh nebulizing unit which is coupled with a Smartcard electronic control unit and its software controls the patient inhalation time, dosage amount and even targets nebulized aerosol to specific regions.
- Several studies are being conducted to improve gene delivery to the lung and to improve administration through nebulization to make sure that maximum amount of vector formulations are deposited to the conducting airways [26].

IV. DISCUSSION

Jet nebulizers are considered inefficient and ultrasonic nebulizes, though light weighted and more silent, are not the best for drug delivery system. Their performance is dependent on many variables and conditions and also similar conditions can cause the nebulizer machine to work differently. The availability of wide ranges of drugs and the number of ways in which a patient can breathe brings out a huge confusion for the user .There is a very little knowledge which is provided to the nursing staff and to the patients who use nebulizers regularly. Moreover, the device is not portable as it has to be connected to the A.C.power supply. The parameters used to measure the efficiency of nebulizer are also not that accurate. A lot of research has been done in this particular field of medicine delivery through nebulization technique and there is a lot more to be done.

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