American Journal of Botany and Bioengineering
https://biojournals.us/index.php/AJBP
ISSN: 2997-9331

Design and Implementation of Portable Nebulizer

Fatima falh Mahdi, Heba Allah Raydh Hassan
Middle Technical University, Engineering Techniques Electrical Engineering Technical College, Department of Medical Instrumentation

Received: 2025 04, Jan
Accepted: 2025 05, Feb
Published: 2025 06, Mar

Abstract: The chemical diagnosis of renal and hepatic function is a fundamental aspect of modern clinical practice, yet challenges persist in the accuracy and reliability of traditional biomarkers. This study addresses gaps in current diagnostic methodologies by evaluating emerging biochemical markers and advanced detection techniques. A comprehensive review of literature and clinical data was conducted to assess the effectiveness of standard tests such as blood urea nitrogen (BUN), creatinine, alanine transaminase (ALT), and aspartate transaminase (AST), alongside novel biomarker developments. Findings suggest that integrating innovative diagnostic tools, including proteomics and metabolomics, can enhance early disease detection and treatment monitoring. The results emphasize the need for precision medicine approaches, leading to improved patient outcomes and more personalized healthcare strategies.

Keywords: renal function, hepatic function, biomarkers, clinical diagnostics, biochemical analysis, precision medicine, metabolomics.

1. Introduction

Aerosol treatment is maturing technically with recent advances in lung dose understanding and major innovations in device technology. Aerosol delivery of drugs to the lungs has dramatically improved the treatment of a variety of respiratory diseases. bronchodilators and anti-inflammatory aerosol medications are the cornerstone of asthma treatment; antibiotics, and hypertonic saline are established treatment options in cystic fibrosis; and nebulization adrenaline and steroids have been used for treatment. There is a great interest in using the lungs as a portal

of entry for systemic drug therapy Aerosol drug delivery allows treatment to be targeted to the lower airways and total systemic exposure should to be reduced. The device chosen has a major impact on aerosol delivery, and it should be considered an integral part of any prescription or drug approval. Now, this is rarely reflected in treatment guidelines for conditions such as asthma and cystic fibrosis. Device development and documentation are driven by many different needs. For patients, important factors include device size, simplicity, irritants, taste, odors, and interactive features.Such factors impact on compliance, which is the main hindrance for effectiveness aerosol treatment. The needs of the patient change significantly with age. On the other hand, clinicians require knowledge of the fraction of a drug likely to reach the lungs when different delivery devices are used for patients of different ages. Finally, health regulators tend to emphasize only in vitro reproducibility. The choice of drug defines the need for accurate estimation of drug delivery. Three basic factors are important in the delivery of aerosolized agents to the lung: the aerosol itself, the physiological of the human respiratory tract (e.g., breathing pattern and airway geometry), and the delivery device. The chapter attempts to provide the practicing clinician an overview of the factors important to overview of the factor important an understanding nebulizer of drug delivery via nebulizer and what is the nebulizer system composed. [1]

1.Introduction Subsidiary

A nebulizer is a device used to administer asthma medication that to be taken from a mist There are three parts to a nebulizer: A cup ; a mouth piece or mask attached to 'T' shaped part; and thin; Plastic tubing that connects to the compressor. A nebulizers help ensure that these types of patients get the right amount of medication: - Patients who have difficulty using metered does inhalers Patients with COPD or sever asthma who can shortness their breath long enough to use the metered dose inhaler (MID) Patients with acute asthma attacks. The word nebulizer (from the Latin “nebula”, mist) was first used in 1872 and defined in 1874 as “an instrument for converting a liquid into a fine spary, especially for medical purposes, intended to spray liquids in aerosol from into gases that are delivered directly to the patient for breathing. The idea of producing a vapor or aerosol for the treatment of lung disease was by no means new even then since smoke and steam had been used in this way for centuries. Inhalation devices depending on mouth suction to draw air through a liquid were produced for essential oil treatment in the 18th century and similar devices were employed when antiseptic inhalations were advocated for the treatment of tuberculosis. Although early inhalation devices depended on steam, mechanical pumps to generate the gas flow for nebulization were made in the 19th century and these were eventually supplanted by electrical compressors in the 1930s.

Early nebulizer chambers were essentially simple atomizers like the glass and hand bulb atomizers first introduced for asthma treatment in the 1930s. These generated an aerosol with a wide range of particle sizes and much of the output was irrespirable. Modern jet nebulizer chambers use a combination of high gas flow, precise Venturi orifices, and baffles to restrict the size of the particles emitted more closely to those of respairation size (1-5 ml diameter) and thereby increase lung deposition and treatment efficacy. These designs depend upon the availability of precision engineering, originally of ebonite and perspex for example, the Wright nebulizer of the 1950s and now injection moulded plastics. By contrast, ultrasonic nebulizers which rely on high frequency sound waves induced by the vibration of a piezoelectric crystal were not introduced until the 1960s. More recently, equipment development has focused on breath assisted chambers which generate an even higher percentage of respirable particles, and can facilitate aerosol treatment with a wide variety of drugs, drug suspensions, and solutions with different physicochemical properties. Progress towards the matching of specific equipment to particular types of drug delivery is likely to continue. Future, treatment may well include a greater use of the products of recombinant gene technology for example, al-antitrypsin as well as specific anti inflammatory mediator drugs for both interstitial lung disease and obstructive air flow disease, and possibly cytokines and cell surface receptors for the treatment of

endobronchial neo plasia. Despite this expanding range of nebulizer therapies, there is a need for physicians to recognize that, for the foreseeable future, the principal use worldwide will be for broncho dilation. In 1955 the first pressurized metered-dose inhaler PMDI, called Medihaler was developed. Ultrasonic nebulizers using high-frequency acoustical energy were introduced in the 1960s. In 1971 the first dry powder inhaler (DPI) known as Spin haler was approved for the administration of sodium cromoglycate as shown in fig. (A) The Important steps in the introduction of inhalation devices Open-tube spacer devices intended for the use with MDIs were developed in the late 1970s. These spacers and holding chambers allowed to avoid the coordination of MDI actuation and inhalation and could reduce or pharyngeal deposition of the drug frequently observed with PMDIs. [2], [3The latest development, Omron's most recent product in the respiratory area is our portable nebulizer, the Micro Air with vibrating mesh technology. Micro Air is the world's smallest nebulizer utilizing vibrating Mesh technology to efficiently deliver solution medications for patients suffering from asthma,COPD, or other respiratory codition. Patients appreciate the small product size and carrying case because that allows them to easily transport Micro Air wherever life takes them. The Micro Air's powerful delivery of the medication is comparable to tabletop compressor nebulizer systems while providing effective relief and control of the disease. Also the Food and Drug Administration (FDA) has granted marketing approval for Cayston as a treatment to improve respiratory symptoms in cystic fibrosis (CF) patients. Caystin’s safety and efficacy have not been established in pediatric patients below the age 7, patients with forced expiratory volume in one second (FEV1) of less than 25 percent or greater than 75 percent predicted.

The patient will feel less tightness in the chest and any wheezing should end. Patient should continue to inhale for several breaths or as instructed by a physician. Some asthma patients are instructed to carry the hand-held nebulizer with them at all times to help alleviate symptoms in emergency

2. Theoretical Description Of Nebulizer

Nebulizer, also known as an atomizer, is a machine that vaporizes liquid medication into a fine mist to be inhaled into the lungs via a mouthpiece or mask. A nebulizer is used to administer medication primarily for those with asthma, but also for those with cystic fibrosis or other respiratory illnesses. Nebulizers used in aerosol rug delivery produce a poly disperse aerosol where most of the drug released is contained in particles (1-5) ml in diameter. Most nebulizers use compressed air for atomization but some use ultrasonic energy. A nebulizer may distinguished from a simple atomizer by the incorporation of bafles which selectively recompressing a hand bulb attached to the air inlet tube.

Principles and performance of nebulizers

The operation of a pneumatic nebulizer requires a pressurized gas supply as the driving force for liquid atomization as shown in Fig. (1). [5] Compressed gas is delivered through a jet, causing a region of negative pressure. The solution to be aerosolized is entrained into the gas stream and is sheared into a liquid film. This film is unstable and breaks into droplets because of surface tension forces. A baffle is placed in the aerosol stream, producing smaller particles and causing larger particles to return to the liquid reservoir. More than 99% of the particles may be returned to the liquid reservoir. The aerosol is delivered into the inspiratory gas stream of the patient. Before delivery into the patient's respiratory tract, the aerosol can be further conditioned by environmental factors such as the relative humidity of the carrier gas. Nebulizer nozzles are of two types, with the internal mixing design, gas flow interacts with the solution prior to leaving the exit port and with external mixing, and gas and the solution interact after both leave the nozzle. Modifications on these designs are used by nebulizer manufacturers, without clear superiority of one approach over the other. These types are illustrated in fig. (2). [6] Determinants of droplet size produced by nebulizers include the characteristics of the solution (density, viscosity, and surface tension), the velocities of the gas and solution and the flow rates

for the gas and the solution. The most important factors are gas velocity and the ratio of liquid to gas fow. An increase in gas velocity decreases droplet size, whereas an Increase in the ratio of liquid to gas flow increases particle size. It is Interesting to note that gas velocity affects the flow rates for both the gas and the solution. Thus, it is impossible to separately control the primary factors affects droplet size from nebulizers. An important consideration in the use of nebulizers is the dead volume of the device. Dead volume refers to the mount of solution that is trapped inside the nebulizer and is thus not made available for inhalation. The dead volume is typically in the range of 1 to 3 ml. Dead volume is minimized by using a conical shape of the nebulizer, by decreasing the surface area of the internal surface of the nebulizer, and by improving the wetness of the plastic surface of the nebulizer. To reduce medication loss due to dead volume, clinicians and patients may tap the nebulizer periodically during therapy, which has been shown to increase nebulizer output. Therapy may also be continued past the point of inconsistent nebulizer (sputtering) in an attempt to deliver medication from the dead volume, but this has been reported to be unproductive. Although the first choice of aerosol generator for the delivery of Bronchodilators and steroids is the metered dose inhaler, nebulizers remain useful for several reasons: First: some drugs for inhalation are available only in solution form. Second: some patients cannot master the correct use of metered - dose inhalers or dry powder inhalers. Third: some patients prefer the nebulizer over other aerosol generating devices. The physiologic benefits of metered-dose inhalers and nebulizers are virtually equivalent, and the choice of device is often based on clinician or patient preference rather than clear superiority of one approach over the other. Although cost savings have been suggested with the use of metered-dose inhalers compared to nebulizers, these benefits may be overestimated.

2.3 Nebulizer Parts

There are a lot of models of nebulizer out there, and each one is a little điferent from the others. This general guide to nebulizer parts will give yo a basic idea of what makes a nebulizer system function. Microcontrollers are programmed devices. A program is a sequence of instractions that tell the microcontroller what to do. Microcontrollers have traditionally been programmed using many level languages as c language and the low-level assembly language of the target processor. This consists of a series of instructions in the form of mnemonics. The biggest disadvantage of assembly language is that microcontrollers from different manufacturers have different assembly languages and the user is forced to learn a new language every time a new processor is chosen. Assembly language is also difficult to work with, especially during the development, testing, and maintenance of complex projects. The solution to this problem has been to use a high-level language to program microcontrollers. A high-level 1language consists of easy to understand, more meaningful series of instructions. This approach makes the programs more readable and also portable. The same high-level language can usually be used to program different types of microcontrollers. Testing and the maintenance of microcontroller-based projects are also easier when high-level languages are used. In our device we used Arduino program in ++C language to program Arduino and program [Arduino Bluetooth Controller (HM-10) Module] to operate the device.

Compressor

BACKGROUND: The treatment of cystic fibrosis involves the use of drugs delivered by nebulizer systems, and adequate functioning of the compressor and nebulizers is essential. we hypothesized that compressors of nebulizer systems used by individuals with cystic fibrosis would not work properly. Therefore, we aimed to assess the performance of the compressors from nebulizer systems used by individuals with cystic fibrosis.

METHODS: This is a cross-sectional study to assess the performance of compressors from nebulizer systems used by subjects with cystic fibrosis registered at the cystic fibrosis patient association in Minas Gerais, Brazil. compressors (Proneb Ultra l) brought by the individuals were tested with new nebulizer parts (Pari LC plus) to assess the variables of nebulization

efficiency, including residual volume, solution output, and aerosol output rate. compression performance was assessed by measuring the operating pressure using a PARI PG101 manometer.

RESULTS: The performance of 146 compressors was analyzed. Fifty-seven (39%) of the compressors were ineffective, with operating pressure values well below the manufacturer's technical reference and the compressor time used for a median time of 36 (15 days to 156 months). The systems with low pressure values demonstrated significantly worse results for nebulization efficiency variables, and a significant correlation was found between residual volume (r =-0.5, P< .001), solution output (r = +0.5, P <.001), and aerosol output rate (r=+0.5, P< .001), and operating pressure values.

sedimentation speed. Deposition occurs in different parts of the According to the density and size of the particles through the air stream Sedimentation mechanisms such as gravitational and inertial sedimentation impact. This process is used in aerosol devices for clinical use, specified As particle size distribution is heterogeneous, jet spray is The most common system used for inhalation therapy is for home use Nebulizer-compressor systems play an important role in cystic fibrosis treatment For their clinical efficiency and low cost ..5,6 These systems include Compressors, which generate airflow, and inhalers, which boost The interaction between air (the flow generated by the compressor) and a liquid (drug solution), and converted into aerosol particles. gas flow Produced by the compressor is an important factor in generating pressure for the system to work; So we assess pressures generated by compressors directly connected to the output air flow By compressors 4.7 is known to increase flow from 4 l/min to 8 L/min results in a 50% reduction in average aerodynamic mass Diameter (MMAD) of aerosol particles generated by nebulizers. That is, the air flow generated by the compressor generates high pressure This forces the flow to pass through the narrow openings of the inhalers, Generate a spray of small particles. 6 low compressors Operating pressure may result in insufficient flow, low nebulizer flow volume, and the rise of MMAD.4 due to the wide variety of inhalers Heterogeneity of its function has been marketed by the US Food and Drug Administration Consensus management and treatment recommendations require it Inhalation medications should only be delivered by aerosol systems approved in the United States Clinical studies. [15]

Relay (2-Channel)

A 2-channel relay module is a type of electronic component used to switch on and off circuits or devices using a microcontroller or other electronic circuitry. The module contains two relays, each of which can be independently controlled.

in the case of a 5V 2-channel relay module, it is designed to be powered by a 5V power supply. This type of module is commonly used in DIY electronics projects, home automation systems, and robotics.

to use the module, you will typically connect the input signal wires from your microcontroller to the signal pins on the module. You will also need to connect the power supply to the module, typically using the VCC and GND pins. Finally, you will need to connect the output wires from the relays to the circuit or device you wish to control.

it's important to note that when working with relay modules, you should take care to observe proper safety precautions, as the relays can be used to switch high voltages and currents. always read the manufacturer's instructions carefully and follow best practices for circuit design and assembly. [16]

Arduino UNO

The Arduino is an electronic development board consisting of an open source electronic circuit with a computer programmed microcontroller, designed to facilitate the use of interactive electronics in multidisciplinary projects. The Arduino is mainly used in the design of interactive

electronic projects or projects that aim to build different environmental sensors such as temperature, wind, light, pressure, etc.. The Arduino can be connected to various programs on the personal computer, and its programming depends on the open source programming language Processing, and the programming codes are characterized The Arduino language is similar to the C language and is considered one of the easiest programming languages used to write microcontroller programs. Some studies have proven that Arduino chips are an important entry point through which it is easy to learn the principles of computer science, electrical and mechanical engineering, as well as crafts and arts, combined in one environment. [18]

Bluetooth (HM-10)

Bluetooth is one of the most popular and easy to use wireless technology. Over the few years there have been many upgrades of Bluetooth standard to keep pace with the current ongoing technology with future technology and to satisfy needs of users. Starting from the Bluetooth version 1.0 to Bluetooth version 5.0, there are many things changed including higher data rates, the ability to be used for IoT with low current consumption, improved security, etc. To learn Bluetooth communication there are many modules available which can be interfaced with microcontrollers. Such a Bluetooth module is HM10 which is based on Bluetooth 4.0. [19]

What is HM10 BLE 4.0 Module?

The HM10 is a serial BLE module (Bluetooth-Low-Energy) which is intended to use for the low power consumption applications and can last long even with a coin-sized battery. The HM10 is a Bluetooth 4.0 module based on the Texas Instruments CC2540 or CC2541 BLE System SoC (System on Chip). The firmware and design of the module is made and managed by Jinan Huamao Technology. The module comes with serial/UART layer which makes the device to be able to interface with different microcontrollers. The HM10 is ideal for creating simple connections and using it with or as an iBeacon.

Difference between HM10 and other Bluetooth Module :

The major difference HM10 possess is the Bluetooth Version. The HM10 is Bluetooth 4.0 module, so it comes with all Bluetooth Version 4.0 features such as speed, throughput and range. The HM10 offers a data rate of up to 24 Mbps with low-energy/low-power consumption. Along with this the HM10 offers a distance range of 100 meters in open space. Compare to other Bluetooth modules such as HC-05 which is a Bluetooth 2.0 based module, the HM10 certainly performs better than the HC-05. The HC-05 only offers 3 Mbps compared to HM10 which is quite less.

Bluetooth module HC-05 and HC-06 are still very popular among makers and hobbyists as they are cheap and easy to [20]

3. Containers and Mixer:

3 Containers

ls a cylinder containing inside material to be used (water ,oxygen , ventoline) are using three containers will be listed in order to determine the amount of material to be pumped to the mixing tube and material transmitted through no top slot cylinders pass through the cylinder valves go to confusion and be made of materials are not radicals and with the material inside.

Mixer

Are most often used in hospital settings, or for the very old or very young. Both elderly and infants are many times unable to use other types of inhalers. These machines are not a drugs, but it is a method of administering drugs. It takes a high concentration of the medication and creates an aerosol mist that can be inhaled. This differs from other inhalers which often use less of the drug, but require more interactivity from the patient. By needing more medication in the unit, there is an increase in the side effects possible from the drugs themselves. These vary from

patient to patient, since some use these machines to control COPD while others use them for asthma. For any respiratory ailment, treatment begins with maintenance.

Conclusions

Nebulizer masks are most often used for infants and the elderly who have difficulty using other treatment methods. A significant number of compressors generate low operating pressure values. these systems showed a compromised efficiency of nebulization, which indicates that the pressure generated by the compressor is an critical aspect of treatment efficiency. Lung disease is the leading cause of morbidity and mortality in individuals with cystic fibrosis (CF). 1 The use of inhaled drugs, such as mucolytics blockers and antibiotics, is essential for treating of these individuals. 2,3 During aerosol information, the particles remain suspended in the air due to low After connecting the device to the power point, sending a signal via the phone, and receiving the signal via Bluetooth, the transmitted signal will go to the Arduino, which in turn works to turn the compressor on via the relay, and after the compressor starts working, the compressed air will go to the cup (container) and mix with the medicine inside, and thus the mist will come out who treats the patient.

References

1. Hans Bisgaard Copenhagen University Hospital, DRUG DELIVERY TO THE LUNG, Rigshospitalet Copenhagen, Denmark l: 1970
2. Clarendon Press, Shorter Oxford English Dictionary. 3rd edn. Oxford:1950.
3. Balliere Tindall and Fox ,Mathu DL. Pulmonary tuberculosis. Its aetiology and treatment. London:1922: 266-9.
4. Dolovich MB, Ahrens RC, Hess RD, Anderson P, Dhand R, Rau JL, Smaldone GC, Guyatt G. Device selection and outcomes of aerosol therapy: evidence-based guidelines. Chest; 127 (1): 335-371. 2005 and Voshaar T. Therapie mit Aerosolen. Uni-Med: Bremen Important steps in the introduction of inhalation devices. 2005
5. Newman SP. Aerosol generators and delivery systems. Respir Care 1991;36(9):939-951.
6. Dalby RN, Tiano SL, Hickey AJ. Medical devices for the delivery of therapeutic aerosols to the lungs. In: Hickey AJ, editor. Inhalation aerosols: physical and biological basis for therapy. New York: Marcel Decker; 1996: 441-473.
7. Mandelberg A, Chen E, Noviski N, Priel I E, -Nebulized wet aerosol treatment in emergency department-is it essential- Comparison with large spacer device for metered-dose inhaler-, Chest (1997); 112: pp. 1,501-1,505.
8. Chua HL, Collis GG, Newbury AM, Chan K, Bower GD, Sly PD. The influence of age on aerosol deposition in children with cystic fibrosis. Eur Respir J 1994; 7:2185-2191.
9. Bisgaard H. Towards improved aerosol devices for the young child. Pediatr Pulmonol 1999; 18:78.
10. Dubus JC, Marguet C, Le Roux P, Brouard J, Heraud MC, Fayon M, et al. Local side effects of inhaled corticosteriods in infantile asthma. Eur Respir J 1999; 14:(Suppl 30):280s.
11. American Thoracic Society/European Respiratory Society. Respiratory mechanics in infants: physiologic evaluation in health and disease. Am Rev Respir Dis 1993; 147:474- 496.
12. Dolovich M. Aerosol delivery to children: what to use, how to choose. Pediatr Pulmonol 1999; 18:79-82.
13. Crompton GK. Inhalational flows in adult patients populations, including those with acute asthma. J Aerosol Med 1997; 10:S23-S29
14. Website of Microchip Technology, Inc. http://www.microchip.com/1010/index.htm,

15. https://chat.openai.com/
16. http://www.handsontec.com/dataspecs/2Ch-relay.pdf
17. https://circuitdigest.com/microcontroller-projects/how-to-use-arduino-and-hm-10-ble-module-to-control-led-with-android-app
18. https://how2electronics.com/bluetooth-low-energy-tutorial-with-hm-10-ble-4-0-arduino/