AUTOMATIC CONTROL SYSTEM FOR REDUCING DRUG WASTAGE IN NEBULIZER

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ABSTRACT— Nebulization is a medical process for administering medicine directly to the lungs by inhalation. This process is achieved by the use of nebulizers which convert the liquid medicine into aerosols. Due to its effectiveness, adaptability and ease of use, jet nebulizers are widely used to administer large doses of inhaled medication. Although nebulization therapy is effective in the treatment of asthma, pneumonia, and other chronic obstructivediseases, there arises a need to consider the amount of medicine wasted during this process. Most nebulizers are operated continuously throughout the entire therapy. But, since inhalation consists of only one third of the respiratory cycle, the rest of the aerosol is wasted during exhalation. That is to say, about 66% of the liquid medicine is wasted during exhalation and only a smaller percentage of 20% reaches the desired site effectively. The model proposed here aims at ensuring the optimum usage of drugs and to reduce its wastage during medication. In the proposed model, a pressure sensor is installed in the mouthpiece or mask of the jet nebulizer, to detect the pressure changes during the respiratory cycle. The pressure sensor is then connected to a valve that controlsthe delivery of aerosols to the patient. Exhalation causes the pressure gradient to rise up.This pressure change is sensed by the sensor and results in the closure of the valve. The electric signal sent to the circuit pauses the compressor form producing aerosols with thehelp of a relay. Thus, the aerosols are not delivered to the patient during exhalation. During the process of inhalation, the pressure is reversed. This allows the compressor to continue producing aerosols and the valves are opened allowing the person to inhale the aerosol. This model provides a good administration of drug delivery thereby reducing thedrug wastage by more than 50%.

INTRODUCTION

Respiratory diseases hinder the daily activities of the affected people anddiminishes the quality of their life. Nebulization forms an important part of the treatment ofrespiratory diseases such as asthma and COPD. Here by, we have proposed a project modelwhich will aid in increasing the efficacy of the nebulization therapy. Nebulization is a medical process for administering medicine directly to the lungs by inhalation. This process is achieved using nebulizers which convert the liquid medicine into aerosols. Due to its effectiveness, adaptability and ease of use, jet nebulizers are widely used to administrate large doses of inhaled medication. Although nebulization therapy is effective in the treatment of asthma, pneumonia, and other chronic obstructive diseases, there arises a need to consider the amount of medicine wasted during this process. Most nebulizers are operated continuously throughout the entire therapy. But, since inhalation consists of only one third of the respiratory cycle, the rest of the aerosol is wasted during exhalation.

About 40% of the liquid medicine is wasted during exhalation and only asmaller percentage of 20% reaches the desired site effectively. The model proposed here aims at ensuring the optimum usage of drugs and to reduce its wastage during medication. In the proposed model, a pressure sensor is installed in the mouthpiece or mask of the jet nebulizer, to detect the pressure changes during the respiratory cycle. The pressure sensor isthen connected to a valve that controls the delivery of aerosols to the patient. Exhalation causes the pressure gradient to drop down. This pressure change sensed by the sensor resultsin the closure of the valves. Thus, the aerosols are not delivered to the patient during exhalation. During the process of inhalation, the pressure is reversed and the valves are opened allowing the person to inhale the aerosol. This model provides a good administrationof drug delivery thereby reducing the drug wastage by more than 40%.

OBJECTIVE

This project has been designed with an objective to develop an effective nebulizermodel to minimize the wastage of liquid medication during nebulization therapy. The model aims to provide a feasible solution to reduce drug wastage in jet nebulizers in order to increase the positive outcome of the treatment.

LITERATURE REVIEW

[1] Newman SP, Clarke SW. Therapeutic aerosols. The inferences made from this paper is as follows:As the end organ for the treatment of local diseases or as the route of administration for systemic therapies, the lung is a very attractive target for drug delivery. It provides direct access the site ofdisease for the treatment of respiratory diseases without the inefficiencies and unwanted effects ofsystemic drug delivery. It provides an enormous surface area and a relatively low enzymatic, controlled environment for systemic absorption of medications. But it is not without barriers. Airway geometry, humidity, clearance mechanisms and presence of lung disease influence the deposition of aerosols and therefore influence the therapeutic effectiveness of inhaled medications.A drug's efficacy may be affected by the site of deposition in the respiratory tract and the delivereddose to that site. To provide an efficient and effective inhalant therapy, these factors must be considered. Aerosol particle size characteristics can play an important role in avoiding the physiological barriers of the lung, as well as targeting the drug to the appropriate lung region. Thetype of inhalation devices and drug formulation are determinants of the drug aerosol's particle size. In Part II, the inhalational delivery devices' and drug formulations' effect on the therapeutic effectiveness of aerosolized drug therapy will be reviewed.

[2] Mukhopadhyay S, Singh M, Cater JI, Ogston S, Franklin M, Olver RE. Nebulized Antipseudomonal Antibiotic therapy in cystic fibrosis: a meta-analysis of benefits and risks. Delivered to ventilated areas to lower total medication with lower cost. Irritant effort on airways.Limitation of airway dose due to respiratory symptoms. Although inferences drawn from individual randomised controlled trials concerning the benefits and risks of this form of therapy are conflicting, pooled effect size establishes benefit with nebulised antipseudomonal antibiotic therapy and emphasises its relevance to the integration of information in other areas of controversyrelating to the treatment of this disease

[3] Touw DJ, Brimicombe RW, Hodson ME, Heijerman HGM, Bakker W. New formulations of old antibacterials have been demonstrated to be efficacious, but proof that high target site concentrations following aerosolized administration compared to oral or intravenous administration translate into greater clinical and/or bacteriological efficacy is missing. The respiratory tract of CF patients represents a complex local microbiome in which many different bacterial species either coexist or compete with each other. Longitudinal, multistaged changes in the CF microbiome are associated with a deterioration of lung function; within-patient pathoadaptive responses select for resistant genotypes and phenotypes even in the absence of antibacterials. Therefore, total viable counts of CF pathogens and their susceptibility patterns are probably misleading markers of infection or exacerbation and not helpful as guides for therapy decisions. Furthermore, the use of conventional PK/PD surrogates correlating pharmacokinetics in serum with clinical cure and presumed or proven eradication of the pathogen as a basis for PK/PD investigations in CF patients is irrelevant, as the minimization of systemic exposure but optimization of target-site-specific exposure is one of the main objectives of aerosolized therapy. Thus, disease-specific PK/PD surrogates should be derived from adequately designed studies. Susceptibility data that are representative of the entire bacterial population should be determined, and the relevant matrix for PK analysis as well as the PK/PD target to be met should be defined. Other patient populations with chronic lung infections may benefit from such efforts, as aerosolized therapies are currently being examined, e.g., for the treatment of chronic obstructive pulmonary disease (COPD).

[4] Kendrick AH, Smith EC, Denyer J. Nebulizers - fill volume, residual volume and matching of nebulizers to compressor. Easy to use by tidal breathing. Suitable for patient with severe disease.Large primary droplet size. Inconvenient and not portable. The use of an inhaler by a patient hasa strong scientific basis that is related to the dose of drug that is deposited into the lungs. Becausethe dose delivered to the lungs is so dependent on the correct use of the delivery system, those who prescribe inhaler devices should ensure that patients can and will use them correctly. This requires that prescribers: know the devices that are currently available to deliver the prescribed drugs and the various techniques that are appropriate for each device; are able to evaluate the patient's inhalation

technique to be sure they are using the devices properly; and ensure that the inhalation method is appropriate for each patient. This Task Force report provides considerable information about the correct use of these devices, including detailed information about drugs thatare currently available for delivery with specific devices, detailed instructions on how to use specific inhalers, guidelines for how to determine what device is best for your patient at home andin hospital, as well as numerous recommendations to ensure that your patient understands how touse the device you prescribe

[5] Pedersen S. Inhalers and Nebulizers: Which to Choose and Why. High lung deposition. High residual volume of drug. Require a minimum 2ml volume. Long nebulisation time. In conclusion,current guidelines for treatment of patients with COPD recommend bronchodilator delivery with nebulizers for patients experiencing acute breathlessness. In patients with stable disease, inhalers are generally recommended for maintenance therapy, and the use of nebulizers in this setting is often discouraged. In this article, we reviewed the weak scientific evidence that forms the basis for the latter recommendation. Recent investigations, especially those that include patient perceptions as an outcome measure, do not support the equivalence of bronchodilator therapy withnebulizers and inhalers. Indeed, if patients with stable COPD experience greater symptomatic benefit with nebulizers, then withholding nebulizer therapy from those patients may be denying them the ability to better control their symptoms, reduce acute exacerbations, and enhance their quality of life. We recommend well-designed comparative efficacy and safety trials with LABA/LAMA combinations, with or without ICS, administered by inhalers versus nebulizers to evaluate the role of nebulizers for maintenance therapy in patients with stable COPD.

[6] Newman SP. Nebulizer therapy: scientific and technical aspects. It helps in loosen mucous in lungs. It is expensive, difficult transportation and requries oxygen or electrical power. As more efficient pulmonary delivery devices and sophisticated formulations become available, physicians and health professions will have a choice of a wide variety of device and formulation combinations that willtarget specific cells or regions of the lung, avoid the lung's clearance mechanisms and be retainedwithin the lung for longer periods. The more efficient, user-friendly delivery devices may allow for smaller total deliverable doses, decrease unwanted side-effects and increase clinical effectiveness and patient compliance.

[7] Loffert DT, Ikle D, Nelson HS. A comparison of commercial jet nebulizers. Many drug solution candeliver combinations. Treatment time variation and Poor portability are the disadvantages. Aerosoltherapy is commonly used in pulmonary critical care. Although inhaled agonists and anticholinergics are widely used in ICUs, other aerosolized medications are available for the treatment of critically ill patients. Previous studies have demonstrated that many factors influence aerosol deposition in the lower respiratory tract, and the effectiveness of aerosol therapy is technique-dependent. When clinicians understand the scientific basis of aerosol therapy and use a proper technique during the therapy, they can provide effective, consistent, and precise delivery of aerosolized medications. Future research should focus on drug/device development, clinical data on patient outcomes, and standards of practice in critical care to provide adequate information on drug and dosing regimens for critically ill patients, which willhelp clinicians achieve effective and safe delivery of aerosolized medications in critical care

[8] McCallion ONM, Taylor KMG, Bridges PA, Thomas M, Taylor AJ. Jet Nebulizers for PulmonaryDelivery. Int J Pharm chracteristics and their effects on in vitro drug delivery from dry powder inhalers. Minimal patient coordination Required. Can Deliver to all aged Patients. Need for Power Source. Risk For Drug exposure to eye. As more efficient pulmonary delivery devices and sophisticated formulations become available, physicians and health professions will have a choice of a widevariety of device and formulation combinations that will target specific cells or regions of the lung, avoid the lung's clearance mechanisms and be retained within the lung for longer periods.The more efficient, user-friendly delivery devices may allow for smaller total deliverable doses,decrease unwanted side-effects and increase clinical effectiveness and patient compliance.

[9] Kisch GL, Paloucek FP. Metered-dose inhalers and nebulizers in the acute setting. Reduce Oropharyngeal Deposition. No drug Preparation. Device Assemble is Necessary. Additional CostRequired. In view of the clinical benefit, lower cost, more rapid administration, personnel timeexpended and ease of administration, the current data justify the use of MDIs and ADs insteadof SVNs in most cases of acute childhood asthma. In addition, further studies to resolve the remaining questions are warranted.

[10] De Boer AH, Bolhuis GK, Gjaltema D, Hagedoorn P. Inhalation chracteristics and their effects on invitro drug delivery from dry powder inhalers. Non Invasive and Accurate Dosage. Higher Compliance. Unconsious Patient cannont Take Dosage. Low solubility and permability. During thepast five decades, dry powder inhalation became widely available, and has an established key position in the treatment of respiratory diseases. The field has expanded to include not only local therapy for obstructive pulmonary diseases, but also systemic delivery of compounds requiring parenteral application or regimens that might require a fast onset for the desired therapeutic effect. The availability of reliable, cheap, and convenient single-use dry powder inhalation devices could be influential in the development of future vaccination strategies and is likely to become increasingly important in the therapy of respiratory infections.

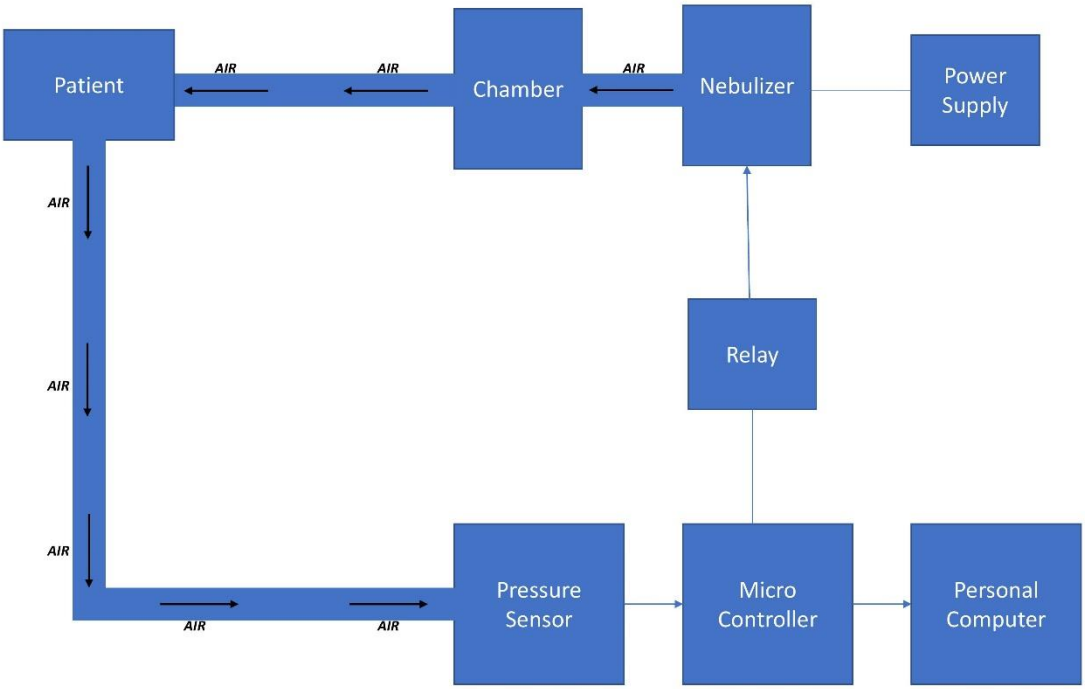
BRIEF METHODOLOGY

A jet nebulizer works based on Bernoulli's principle. The compressed air passingthrough a narrow orifice creates a low pressure in the liquid feeding tube. This evacuates the solution with the drug being drawn up from the fluid reservoir and shattered in the gas streamas fine droplets. These droplets are delivered to the patient through the mouthpiece. This project uses a pressure sensor for sensing the pressure in mouthpiece and a solenoid valve to switchthe drug delivery. The pressure sensor fitted at the mouthpiece senses the positive and negative pressure from the patient. This creates a voltage difference which is given as inputto the AVR ATMEGA 32 Microcontroller of Arduino UNO. The microcontroller is programmed such away to OFF the drug delivery through solenoid valve during positive pressure and ON in the case of negative pressure. This system minimizes the amount of drugwasted during exhalation which constitutes up to 2/3 of the respiratory cycle by allowing thedrug to be delivered only when there is a negative pressure sensed by the sensor.

Trials	Threshold Voltage Value	Solenoid Valve Nebulizer and On / Off Status
1.	2.303	OFF
2.	1.2323	OFF
3.	2.4904	ON
4.	2.00	OFF
5.	3.4657	ON

CONCLUSION AND FUTURE SCOPE

In the proposed system, we use the pressure sensor and solenoid valve along with the use of relayto reduce the wastage of drug in nebulization therapy. This system can save a huge amount ofliquid medication which will eventually lead to the reduction in the cost of treatment. The simple use of these components in the jet nebulizer can make the entire nebulization process effectiveand cost friendly. This allows patients to benefit more from this treatment than the traditionalprocess. The placement of the SPD102DAhyb sensor in the mouth piece allows us to sense thedifferential pressure given during exhalation and inhalation. The converted electrical signal passedonto the Arduino UNO microcontroller analyses the voltage value received. The preset threshold voltage values in the LabVIEW software allows the microprocessor to send corresponding signalsto the compressor and the solenoid valve attached to the mouthpiece. The presence of the positiveand negative pressure gives rise to the voltage difference which then further leads to the control ofthe compressor and the solenoid valve. Thus, the drug is delivered only during inhalation and ispaused during exhalation. This method can save up to 60% of the drug which is used for the therapy.It enables us to provide a good administration of drug to the required site without considerablewastage.



RESULT

The simple use ofthese components in the jet nebulizer can make the entire nebulization process effective and costfriendly. This allows patients to benefit more from this treatment thanthe traditional process. Theplacement of the SPD102DAhyb sensor in the mouth piece allows us tosense the differential pressuregiven during exhalation and inhalation. The converted electrical signalpassed onto the Arduino UNOmicrocontroller analyses the voltage value received. The preset threshold voltage values in the LabVIEW software allows the microprocessor to sendcorresponding signals to the compressor and thesolenoid valve attached to the mouthpiece. The presence of the positive and negative pressure gives rise to the voltage difference whichthen further leads to the control of the compressor and the solenoid valve. Thus the drug is delivered onlyduring inhalation and is paused during exhalation. This method can saveupto 60% ofthe drug which is used for the therapy. It enables us to provide a good administration ofdrug to therequired site without considerable wastage.

Before the Proposed System was Imposed

Trials	Actual Volume	Deposited volume
1.	40 ml	5.23 ml
2.	50 ml	5.1 ml
3.	60 ml	5.9 ml
4.	80 ml	7.22 ml
5.	90 ml	10.1 ml

After the Proposed System was Imposed

Trials	Actual Volume	Deposited Volume
1.	40ml	24.0 ml
2.	50ml	31.34 ml
3.	60ml	37.9 ml
4.	80ml	45.57 ml
5.	90ml	60.33 ml

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[10] Clay MM, Pavia D, Newman SP, Clarke SW. Factors influencing the size distribution of aerosols from jet nebulisers. Thorax 1983;38:75