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Physiological Parameters Used To Monitor Asthma

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***Abstract*- Asthma is a respiratory condition which is chronic in nature and is highly prevalent. The symptoms are shortness of breath, cough, wheeze and chest tightness. Asthma is described by correctable airflow obstruction, hyper- responsiveness and inflammation of the airways. Severe exacerbation accelerates the loss of lung function. This paper deals with investigating sundry physiological functions that can be used to monitor Asthma and chronic obstructive pulmonary disease (COPD). There is lack of resilient methods to continuously monitor Asthma as there are many environmental triggers that springs asthma and persistently monitoring them remains a challenge. Thus their remains a growing need of asthma management.**

***Keywords*- Asthma, COPD, exacerbation, heart rate, wheeze, respiratory rate, Pulse oximetry**

I. INTRODUCTION

Chronic Obstructive Pulmonary Diseases along with diabetes and chronic heart diseases are usual group of chronic diseases. Asthma is highly entitled among pulmonary disorders. Globally, the estimation is that there are 300 million asthma sufferers [1].

Around ten percent of total population of children is asthmatic. And it is estimated that by the year 2025, asthma patients will increase by 100 million [2]. This will move the expenses of healthcare system for patient treatment along with increase in medical staff workload.

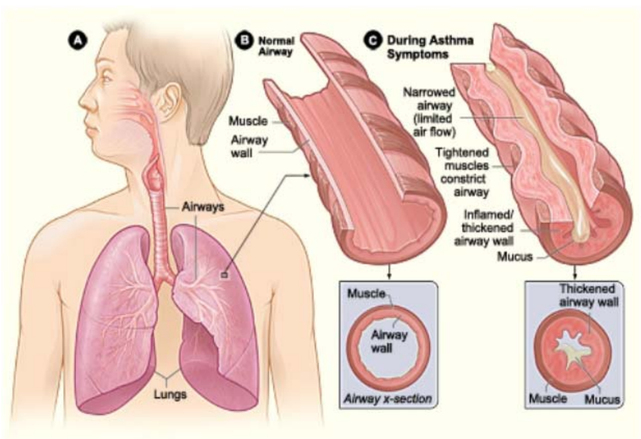

Fig.1. Showcase of asthmatic broncho-constriction [4].

A. Definition, pathology of asthma

Asthma is a condition in the respiratory system which is mainly due to filling up of spasm in the lung's bronchi which causes hindered breathing. It is usually related to some form of hypersensitivity or a reaction to allergy.

The periods of obstruction exacerbations (attacks) and calming periods recurs. Wheezing, dyspnea (shortness of breath), cough and chest tightness are the symptoms of the asthma attack. They occur mainly when the tracheobronchial smooth muscles (bronchospasm) contracts or oedema, when an excess of watery fluid in cavities or due to hyper-secretion of mucus. This results in Broncho-constriction (contraction of airways) [3] and is shown in Fig. 1 and thus narrowing the airways.

Among the total asthmatics, around 70% of them are due allergies [1]. In the environment, various triggers that induce immunoreaction and causes asthma due to allergy are dust-mites, smoke, pollen from plants, fur, feather, atmospheric weather conditions etc.

Among the lung sounds, wheeze is an adventitious one and is defined as abnormal, clinically. These adventitious sounds are continuous in nature and they superimpose on the normal breath sounds. The presence of wheeze in the lung sound benefits a physician as it assists in diagnosing asthma. The duration of the wheeze, its position and its relation to the respiratory cycle are the key points that assist a physician. Many varieties of pulmonary pathologies for example, COPD (chronic obstructive pulmonary disease), bronchiolitis and most commonly asthma can be diagnosed and managed by this practice.

Stethoscope auscultation is a completely noninvasive technique and is widely used due to its practicality and simplicity of implementation. It is used as a diagnostic method that provides information on the functioning and structure of the respiratory system.

Despite having advantages, auscultation also has its limitations and is not a supreme mode for monitoring the respiratory conditions continuously [5]. Although enhancements have been made in order to have better performances, yet still now few issues and criticality have not been dealt with till now.

This leaves at an individual's experience and hearing skills, that how a physician can recognize and differentiate the lung sounds. Therefore, there remains a consistent subjective component, when auscultation and interpretation of the sounds is done using a stethoscope. Thus, raising a need to go beyond age-old auscultation (digital or not). The acquired signal can be processed with devices that applies calculations automatically (hence removing subjectivity) and auscultation using sensors can be performed on large area over the thorax. Wheeze can be detected, with the aid of electronic sensors and computer technology.

II. MONITORING OF PATIENT'S PHYSIOLOGICAL FUNCTIONS

Wheeze detection, SpO2 (oxygen saturation level), Respiratory rate and hearth rate are the most common physiological parameters used for monitoring asthma. Kaushal P et al presented another non-invasive diagnostic tool that analyzed exhaled breath [10]. Below are some of the physiological functions that have been studied subject to experimental setup, followed by Table I. that shows comparison of physiological parameters.

A. Heart rate

Variations in respiratory sinus arrhythmia (Heart Rate triggered by deep breathing), standing up from the resting position, the Valsalva maneuver, was examined in normal and asthmatic subjects by Kallenbach JM et al [8]. The parasympathetic neural drive which sends signals to the sinoatrial node, which is the natural pacemaker of the heart increased as the respiratory sinus arrhythmia significantly increased in magnitude. When resistant breathing was induced to non-asthmatic patients; it failed to show similar changes. A statistical analysis in a batch of asthmatic subjects, by Kallenbach JM et al suggests that the extent of respiratory sinus arrhythmia is related with bronchial hyper reactivity degree. The finding suggests that due to enhanced respiratory sinus arrhythmia in asthmatic subjects, autonomic nervous activity increases which involves the parasympathetic nervous system, as compared with non-asthmatic patients.

B. Respiratory Rate

Researchers have found that the respiratory rate increases naturally during asthmatic attack [11]. When there is an occurrence of acute asthma, hyperventilation takes place. Kesten S et al monitored respiratory rate for 47 subjects that were acutely ill and 42 non-asthmatic subjects as soon as they arrived in an emergency room with non-cardiorespiratory symptoms. After analyzing them against the subjects in laboratory, they concluded that respiratory rate does not increase when severe airway obstruction is instigated in the laboratory.

C. Oxygen Saturation Level

Pulse oximetry, is another non-invasive assessment of asthma severity as it estimates oxygen saturation.

Oxygen saturation level can indicate which patients having acute severe asthma are likely to have a respiratory failure and would need intensive care, regardless of their inspired oxygen concentration. With, 92% or greater Oxygen saturation, respiratory failure is unlikely. Arnold DH et al [6] prospectively studied subjects, aged 5 to 17, to determine the relationship between oximeter plethysmograph Waveform and %FEV1 (forced exhale volume per second) and how %FEV1 changes in terms of response when treating asthmatic patients with extreme exacerbations.

D. Wheeze

Airway obstructive diseases like COPD (chronic obstructive pulmonary) and asthma has a general sign, which is a wheezy breath. Wheezes have musical character and are adventitious lung sound. Acoustically, wheeze has a periodic characteristic generating dominant frequency above 100 Hz and remains usually >=100 ms.

Fu Y et al [7], presented a distributed wearable sensors for real-time and continuous management of pulmonary disease during the patient's daily activities. The system sends an alert and warns regarding the rising symptoms of asthma exacerbation. As the wheezing is the most defined symptom for asthma, the asthma management focuses on monitoring wheezes.

E. Exhaled Breath Analysis

Human breath consists of CO_2, H_2O vapors, O_2, nitrogen and a number of disparate compounds in tiny quantity.

The breath during expiration can be analyzed real time, in a non-invasive way with a low cost technique.

Asthma can be monitored and diagnosed using this technique. Kaushal P and Mudhalwadkar RP proposed a technique[10] for analyzing exhaled breath, which is done using gas sensors that are made of MOS (metal oxide semiconductor).When crystals of metal oxide such as SnO2 are heated, reaching a specific high temperature, they manifest sensitivity towards oxidizing and it also reduces gases by a variation of their electrical properties. The responses of the sensor have been compared and could distinguish between normal and asthmatic exhaled breaths. The patients with asthma, the decay time increases and the change in resistance is 300kΩ which is less as compared to normal breath exhaled.

TABLE I. COMPARISON OF PHYSIOLOGICAL PARAMETERS:

Author	Parameter	Feature Studied	Conclusion
Kallenbach JM et al	Heart Rate	Mean heart rate, Average of the max and min heart rates	There exhibits a relation between the measure of respiratory sinus arrhythmia to subject's age, respiration rate and mean of heart rate.
Kesten S et al	Respiration Rate	frequency and duration of respiratory phases	Breath rate increases with Asthma attack.
Arnold DH et al	Oxygen Level	pulse oximeter plethysmograph estimate of pulsus paradoxus	Oximeter plethysmograph waveform corresponds with the Validity Criteria i.e. %FEV1 (Forced Expiratory Volume per second) and the response i.e. change of %FEV1 during acute asthma exacerbations treatment.
Kandaswamy A et al	Wheeze Sound	Mean, Average Power, standard deviation of the wavelet transform of the sound signal of the wheeze.	Wheeze sound at frequency between 100 Hz to 1000 Hz can be captured and detected from the lung sound.
Kaushal P et al	Exhaled Breath Analysis	Response duration, Peak resistance, Settling and Preheating duration, Ratio of the Resistances	The Pellet Sensor delivers different response curve that corresponds to features of a spirometer. Pellet sensor could clearly discriminate breath during expiration of asthmatic and non-asthmatic subjects.

III. PROPOSED METHOD

Out of all the physiological parameters discussed in this paper, lung's wheeze sound is the most efficient way to assess pulmonary malfunction. Characteristic sounds are produced due to any chronic changes of the lung, and auscultation gives immediate knowledge regarding the activity of the lung. Digital auscultation is a coherent approach to assess the state of respiratory system by analyzing pulmonary sounds.

A. Kandaswamy et al dealt with a novel method of analyzing the signals from lung sound using wavelet transform [9]. As the lung sound signals are non-stationary, to diagnose and classify wheeze in the lung sounds, the usual practice of frequency analysis does not accomplish the classification. With wavelet transform, a time-frequency representation of the signals was achieved. Daubechie's wavelet of order 8 gave the best results. The signals of the lung sound were decomposed by passing it from high pass filter and low pass filter and 7 sub-bands (6 detailed and 1 approximate) of various frequencies were obtained. Using the wavelet coefficients of each sub-band, statistical features were extracted to outline their distribution.

These statistical features were used as input to Artificial Neural Network (ANN) based system that was used to categorize the lung sound further into 6 categories of one normal and 5 chronic pulmonary sounds (for example: wheeze, crackles etc). A network is trained using feedforward architecture, with two layers and backpropagation (resilient) algorithm. This network was simulated and used to classify the six lung sounds.

The physiological parameter, wheeze in lung sound can be detected on similar grounds and is the proposed one. Out of many techniques, wavelet transformation can identify any fine wheeze in the lung sound, thus detection of asthma attack in an early stage can be accomplished.

IV. CONCLUSION

COPD and Asthma affects the performance of individuals in their day to day lives. Management of pulmonary diseases is vital so as to avoid symptom of flare ups and acute episodes of the disease. There is growing need of disease management that not only improves quality of life, but also reduces the healthcare cost. Physiological parameters can be used for monitoring asthma affectively. This can improve the clinical ability, physician visits and, medication process for an individual and decrease emergency room visits. Continuous monitoring of the physiological functions is necessary for understanding asthma and timely managing it, which can otherwise lead to failure of respiratory system. The study of physiological parameters opens the opportunity of extending asthma management to computer-aided analysis from lab settings to real-time applications.

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