

A Comprehensive Care System to Remote Monitor the Vital Signs in Patients with COPD

G.Apoorva¹, S.Hariharan², K.Kapil Ganesh³, K.Supriya⁴, S.Muthulakshmi⁵

U.G. Student, Department of Biomedical Engineering, Dhanalakshmi Srinivasan Institute of Technology,
Trichy, Tamilnadu, India^{1,2,3,4}

Assistant Professor, Department of Biomedical Engineering, Dhanalakshmi Srinivasan Institute of Technology, Trichy,
Tamilnadu, India⁵

ABSTRACT:Chronic pulmonary disease is one of the leading causes of mortality in the worldwide. It is the chronic disease with long duration and repeated illness that is difficult to cure and required long-term treatment and care. The chronic obstructive pulmonary disease (COPD) is one of the most worldwide spread diseases due to cigarette smoking and air pollution. We propose comprehensive care systems that provide continuous passive monitoring of subjects using mobile sensors can help detect disease estimate severity, track progression over time, and predict adverse exacerbation events. By using this system we aim to decrease the mortality rate by monitoring the vital signs related to exacerbations of COPD and trigger an alert mechanism to alert patients and physicians that interventions can be made in time for the deterioration of patients. In addition to this we also monitor the environmental condition and patients smoking levels. This system also involves the longitudinal use of this comprehensive system among high risk COPD patients in the indoor and outdoor environment to manage them with stable COPD grade by using low cost embedded systems.

KEYWORDS:COPD, vital signs, mortality rate, comprehensive system and alert mechanism.

I.INTRODUCTION

Chronic obstructive pulmonary disease (COPD) refers to a class of lung ailments that leads to serious complications because of breathing deficiency and WHO estimated that by 2030 it will get third ranking in death rate. It is characterized by the symptoms of wheezing, chest tightness, shortness of breath and chronic cough (with phlegm or dry). It may also lead to fatigue, weight loss or obesity and chest pressure. The major causes of COPD are due to smoking (90%), air pollution (20-30%) and deficiency of protein called Alpha-1 antitrypsin (5%) which is congenital defects. Proper monitoring and management of this chronic disease will extend the life expectancy of the patients by providing them with proper prevention and medication. The remote and passive monitoring of vital signs of those patients will reduce the mobility to hospital and saving their money spending and also alert the patients immediately about their ill conditions.

Therefore the COPD course can be divided into acute exacerbation and stable period. Most physicians and patients pay more to patients with COPD about their acute exacerbation and ignore the rehabilitation and management of stable patients. This may result in increase number of patients condition worse. So this kind of remote monitoring will develop an effective care plan of this individuals. This remote monitoring system stimulated the need of reducing the high incidence of this disease. This system provides early warning and complications management such as lung cancer, diabetes, heart attack, depression, pneumonia etc..

According to WHO the management of COPD involves I) reducing the risk factors. II) maintaining them with stable COPD. III) assuring and monitoring disease. IV) exacerbation management. The aim of decreasing the mortality rate and morbidity motivates the work on remote monitoring the vital signs of patients with COPD.

In order to provide care and services by this comprehensive system this is the patients centre point of care devices for this chronic disease management. First this system uses multiple numbers of sensors for monitoring those vital signs through embedded technology. Then finally we use IoT module to trigger an alert mechanism for the detection of

related exacerbation of COPD in time for the deterioration of patients. This will reduce the risk of acute exacerbation, reducing admission rate, mortality, and cost and reducing social and economic losses.

To help reducing cost and performance improvement and elderly-care as well as cognitive service and human centric sensing and computing are needed. These systems collect data from the different sensors and compute it through the IoT module.

II. METHODOLOGY

This method

A patient can use one device alone; each individual device is software-associated with a unique set identifier before fulfilment occurs. The patient can pair only one device over IoT module can pair automatically when other devices in the pack are used. The one-time smart phone-guided setup process guides the patient. There in, the app displays real-time and summary data such as respiration rate, heart rate, SPO₂ respiratory waveform, body temperature, cough, chest compression and also fall detection detected. Each wearable device contain 4.5AH lithium ion battery rated at approximately 1,600 hours (over 60 days) of active use when worn on-body and paired with a smart phone and we are also monitoring environmental characteristics using humidity sensor, gas sensor & smoke sensor. Humid air is dense, due to the high water content. This density can increase airway resistance in the body. As a result, breathing may require more effort, which can worsen COPD symptoms, including shortness of breath and fatigue. The device puts itself in a 'deep sleep' state (drawing 4.5uA) until it is physically rotated with respect to gravity, at which point it assesses whether it is being worn on-body by querying the force sensor to detect a human-like respiratory waveform and the SPO₂ sensor to identify a oxygen rate in the blood. If such patterns are detected, the device begins intermittently transmitting data to the smart phone application over cloud. To sense respiratory effort, a purpose-built force sensor detects changes in pressure against the device that results from thoracic or abdominal excursion. The sensor produces a waveform representing inhalation and exhalation, sampled at 25Hz. This raw waveform can be optionally stored in the cloud for post hoc analysis.

The device senses blood oxygen rate using a SPO₂ sensor that faces the skin. While normally used on the wrist, finger, and ear lobe, PPG can sense changes in blood flow at virtually any place in the body, the torso and abdomen being common sources. To preserve battery, the SPO₂ sample frequency is 5 minutes when the sensor is worn and continuously during sustained physical activity. At each 25 Hz sampling event, the sensor senses changes in blood flow for up to 30 seconds until it identifies a pulse rate with high confidence. The raw SPO₂ data can be optionally stored in the cloud. Humidity, especially if it very high, can worsen COPD symptoms. Other common triggers include pollution, infection, and pollen. A person can reduce indoor humidity by using an air conditioner or dehumidifier. Environmental weather reports can help determine when conditions are suitable for COPD patients using humidity sensor, gas sensor & smoke sensor. Cigarette smoke contains tar and many toxic chemicals that irritate the lungs. Smoking also damages the cilia, the tiny hairs responsible for cleaning the airways.

LEAD ACID BATTERY

In this work we are using lead acid battery, which is electrical storage device that consists of lead plates and an electrolyte that uses a reversible chemical reaction to store energy. The cell voltage is about 2 volts.

PIC MICROCONTROLLER

It is an 8 bit microcontroller unit and can perform without any requirements for additional hardware such as I/O ports and external memory. PIC stands for "programmable interface controller".

ADVANTAGES OF PIC 16F877A

Less malfunctioning Reliable

Fast performance

Less power consumption

ACCELEROMETER

Accelerometer here is used to detect fall detection because COPD not only makes it difficult to breathe, but it can affect mobility & drastically increase your fall.

HEART BEAT SENSOR

The BPM (beats per minute) value for normal person are 72 BPM but COPD patients with the heart beat range of more than 80 BPM it may develop the risk of heart attack and pulmonary hypertension. By monitoring the BPM of those patients will avoid the exacerbations and the mortality rate.

TEMPERATURE SENSOR

For people with COPD, developing a fever can be a sign that the cold is getting worse. The normal range of temperature is about 37 degree Celsius. Sometimes while in the stage of 2 and 3 the temperature extended to the range of 38.5 degree Celsius which is necessary to monitor the body temperature for avoid further exacerbations and risk of death.

SPO2 SENSOR

The currently accepted oxygen saturation target of 88%-92% is an attempt to provide adequate tissue oxygenation while avoiding the complication of hyperoxic hyper apnea by giving the minimum amount of oxygen needed to stay above severe hypoxemia for patients with COPD. So it is mandatory to observe spo2 level of those patients otherwise it will result in pulmonary hypertension.

RESPIRATION SENSOR

The normal respiration rate for an adult at rest is 12 to 20 breaths per minute. If people take more than 20 breaths per minute for at least a few minutes, that condition would be described as tachypnea. Typically, when patients with COPD, may feel a sense of discomfort during episodes of tachypnea. Patients may experience tachypnea when they exert themselves physically or if they develop an infection. Advanced COPD can be associated with frequent episodes of tachypnea, even without triggers. Thus the monitoring of respiration rate will provide proper management.

ACETONE SENSOR

Acetone was detected with the mean values of 715 mg/l in alveolar air (Ca) or 0.2 -1.8 ppm for normal. In COPD patients, chronically elevated carbon dioxide shifts the normal acid-base balance toward acidic. They have severe emphysema, and characteristically are thin and free of signs of right heart failure it results in exceeding the normal range of acetone level in exhaled breath and here this system provide the acetone measurement for maintaining COPD at stable grade.

FORCE SENSOR

Some of the applications of Force sensor that uses force-sensing resistors includes pressure-sensing buttons so that it this kind of sensors are used for detecting chest tightness as COPD affects the lungs in a number of different ways, making it difficult to breathe and resulting in a sensation of chest tightness. The structural lung changes in COPD cause that sensation of chest and lung tightness. Chronic inflammation causes persistent thickening and narrowing of the airways, which results in a sensation of chest constriction. It can also occur with several other medical conditions, some of which are emergencies. If the patients experience gradually worsening chest tightness or sudden chest tightness, you need to get medical attention for that this kind of sensors will provide better result.

HUMIDITY AND GAS SENSOR

Whether outdoors or indoors, air pollution can irritate the lungs and cause COPD symptoms to suddenly flare up. Certain factors can trigger COPD flare-ups, including lung irritants, changes in weather, and infections. Extremes in humidity can also cause COPD symptoms to worsen. High humidity levels may exacerbate symptoms for a variety of reasons. The body must work harder to breathe when humidity levels are high, especially when the air is hot. Alert people about the humidity and pollution to the patients will help to avoid exacerbations.

SMOKE SENSOR

Cigarette smoke contains tar and many toxic chemicals that irritate the lungs. Smoking also damages the cilia, the tiny hairs responsible for cleaning the airways. No one should smoke, but this is especially true for people with COPD. If you have COPD, you should quit immediately. If you have already quit, you should do everything possible to stay smoke-free and to avoid secondhand smoke. These factors can increase the risk of infection and a flare-up of symptoms. It will intimate the physician and patients that smoking will increase the risk.

SOUND SENSOR

COPD can cause your lungs to produce excess mucus, leading to frequent coughing. The effective, or controlled, cough comes from deep within the lungs and has just enough force to loosen and carry mucus through the airways without causing them to narrow and collapse.

Here the sound sensor detect the sound of cough episodes produced by the patients in order to indicate the grade of exacerbation , severity and higher risk .this sensor processing the sound into analog output which help to analyze and monitor the patients.

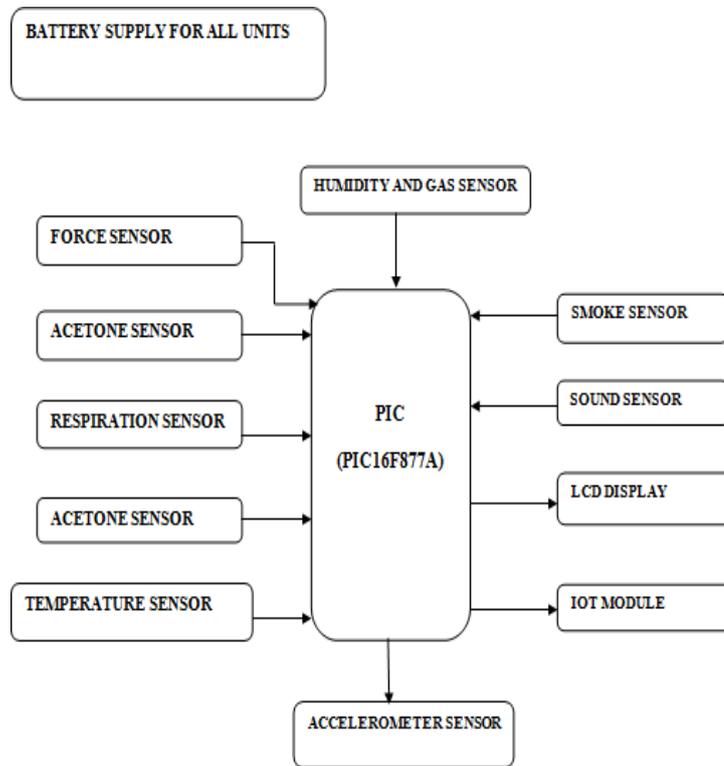


Fig.1. Proposed Model

IOT MODULE

Finally the results produced by each sensor are computed and intimation is provided as alert to the patients, doctors and family members of those patients.

RESULT

This system will definitely be a better tool for the better and happiest survival of COPD patients instead of having fear about the exacerbations of this disease. As a result there will be a decrease in mortality and morbidity rate. Finally this system acts as tracking system that keeps the eye on the vital signs of those patients in order to extend their span.

III.CONCLUSION AND FUTURE SCOPE

An integrated and comprehensive method was envisaged for providing better home care and remote monitoring of COPD patients in order to expanding their life expectancy and will result in the decrement of the increasing death rate caused by COPD. This remote monitoring systems and telemedicine for patients considering a defined criterion based and low- end embedded devices. Furthermore, the large number and variety of available sensors for vital sign monitoring, showed that here is a, huge potential to develop novel system with low operational costs representing an important prospective for patient care centers and physicians in order to decrease the overcrowding medical services.The device has been demonstrated to effectively capture granular, ambulatory respiratory data work among a high-risk, representative, and authentic chronic disease population. Future iterations of the device could include adding additional sensors of use for chronic disease management such as fatigue , weight monitoring and the whole process is developed by machine learning methods in the future work will be more efficient for better management of COPD affected patients.

REFERENCES

- [1] NeemaMoraveji, Phil Golz, Joanne Hollenbach, Mark Holt and Richard Murray “Long-term, Ambulatory Respiratory Monitoring of COPD Patients using Garment- Adhered Sensors” IEEE Instrumentation and Measurement Society, Volume 12, Number 8, pp.99-112, 2019.
- [2] Viswam Nathan, KoroshVatanparvar, MdMahbuburRahman, EbrahimNemati and JilongKuang, “Assessment of Chronic Pulmonary Disease Patients Using Biomarkers from Natural Speech Recorded by Mobile Devices” IEEE, pp.8-17, 2019.
- [3] GuanzhongYang, ChuifengKong and QinpengXu, “A Home Rehabilitation Comprehensive Care System for Patients with COPD Based on Comprehensive Care Pathway” IEEE Instrumentation and Measurement Society, Volume 23, Number 5, pp. 44-57, 2018
- [4] PlinioPuelloMarrugo , Emanuel martinezfranco and Julio Cesar Rodriguez Ribon, “Systematic Review of Platforms Used for Remote Monitoring of Vital Signs in Patients With Hypertension, Asthma and/or Chronic Obstructive Pulmonary Disease”, IEEE Communications, Volume 7, Number 8, pp.34-45, 2018.
- [5] Yang Weng , Yin Fang , Haiying Yan , Yang Yang and Wenxing Hong, “Bayesian Non-Parametric Classification With Tree-Based Feature Transformation for NIPPV Efficacy Prediction in COPD Patients” , IEEE Medical Electronics, Volume 87, Number 12, pp.45-58, 2019.
- [6] AneeshAnand,Daniel Chamberlain, Rahul Kodgule,and Richard Ribon Fletcher, “Pulmonary Screener: A Mobile Phone Screening Tool for Pulmonary and Respiratory Disease”, IEEE, DOI: 978-1-5386-5566-5/18, 2018.
- [7] Jose G. Terius-Padron (2018) “Towards Self- management of Chronic Diseases in Smart Homes” IEEE Workshop on Advanced Technologies for Smarter Assisted Living solutions, 2018.
- [8] Anthony Windmon (2018) “TussisWatch: A Smart-phone System to Identify Cough Episodes as Early Symptoms of Chronic Obstructive Pulmonary Disease and Congestive Heart Failure” IEEE Journal of Biomedical and Health Informatics, Volume 3, Number 11, pp.61-68, 2019.
- [9] .T. Brunschweiler, J. Weiss, S. Paredes, A. Sridhar, U. Pluntke, S. Mai Chau, S. Gerke, J. Barroso, E. Loertscher, Y. Temiz, P. Ruch, and
- [10] B. Michel, “Internet of the Body - Wearable Monitoring and Coaching” , Medical Solutions, Volume 7, Number 1, pp.25-31, 2019.
- [11] Burnett RT, Pope CA, Ezzati M, Olives C, Lim SS, Mehta S, et al “An integrated risk function for estimating the global burden of disease attributable to ambient fine particulate matter exposure” Pub Med, 2018.