A Review paper on Development of diagnostic tools for pathologies of respiratory system using Pulmonary Function Test (PFT)

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Abstract - *Pulmonary function test (PFT) is a test generally used for those patients who are having an abnormal respiration cycle. Spirometry is considered as a gold standard which gives the various parameters of the human respiration including, FVC, FEV1, FEV1/FVC, and PEF, VT. Based on the above given parameters, the human respiratory diseases like Asthma, pulmonary fibrosis cystic fibrosis, respiratory bronchitis and other deficiencies can be identified. This document will presents a diagnostic tool in which virtual instrument is created using a software which creates a user friendly graphical control and monitoring of a system. By the means of digital electronics and Elvis 2+, the data is fed into a Virtual Instrument. The flow-volume and volume-time graphs are been displayed on the Virtual Instrument. Comparison of the obtained graph can be done with the graph of a normal person and the disease like Asthma can be detected. It gives accurate and real time data analysis .*

Key Words: **PFT, spirometry, software, flow-volume &volume-time graph**

1. INTRODUCTION

Obstructive or restrictive lung diseases are the two main classifications of the lung diseases. Among which one of the major pathological disorders is Asthma.

Asthma is a common long term inflammatory disease of the airways of the lungs. In 2013, 242 million people globally had asthma up from 183 million in 1990. [1]It is characterized by reversible airflow obstruction. Wheezing, coughing, shortness of breath and chest tightness are common symptoms of this disease. These symptoms may be observed a few times in a day or few times per week. Depending on the seriousness it may become worse during night or after exercise. According to the frequency of symptoms, Asthma can be clinically classified depending on the values of forced expiratory volume in one second (FEV1) and peak expiratory flow rate.

Pathologies of respiratory system like Asthma can be identified using PFT (pulmonary function test).The primary purpose of pulmonary function testing is to identify the severity of pulmonary impairment. For performing the PFT spirometer is used. It is the single best test for asthma because Spirometry is considered the best technique for diagnosing the obstructive lung disease. Spirometry includes pulmonary mechanics test which includes measurements of FVC, FEV1, FEV1/FVC ratio, FEF values and forced inspiratory flow. Measuring pulmonary mechanics identifies airway obstruction by assessing the ability of the lungs to move large volumes of air quickly through the airways. The use of a fixed lower limit of normal for the FEV1/FVC ratio as proposed by the Global Initiative for Obstructive Lung Disease (GOLD) lacks a scientific basis and results in misclassifying patients at either end of the age spectrum.[5]Young patients are classified as "normal" when airflow obstruction is present, and older patients are classified as showing obstruction when no airflow obstruction is present. The use of the GOLD threshold for identifying airway obstruction should be discouraged in clinical practice where or when computerized predicted values are available.

The result collected by the spirometrer device are used to generate a pneumotachograph which can help to assess conditions of lungs. The data collected will be analyzed on the software based user friendly GUI. This method is non-invasive and the data acquisition can be done at real time. The previous invented methods for asthma detection based on PFT are unable to provide the real time data analysis. The test results are reflection of human respiratory status. The diagnosis can be done on the rate of individual’s inhalation and exhalation. Diseases like Asthma, Chronic Obstructive Pulmonary Disease (COPD), restrictive diseases are responsible for making changes in graphical representation of flow-volume. So depending on deviation we can establish a methodology of detecting a disease.

2. Previous work

1 - Remote PFT using depth sensor

The author used a Microsoft Kinect depth sensor for measuring the chest volume. Kinect sensor placed above the patient body and obtains average depth values of 16 regions of interest on chest and abdomen to analyses their motion. In this the estimated chest volume is obtained by summing distance of each pixel from camera which provides means value of chest region. Volume vs. time and flow vs. volume curve is obtained by first order derivative and can be obtained for each sequence by estimating chest volume as a function of time.[1]

Drawback – Motion Artifacts , Requires both FVC & SVC Parameters

2. Convenient pulmonary volume and flow detection system

In this paper the author developed a technique for identification of respiratory disease through impedance pulmonary function measurement system (IPFS). In this the tetra polar electrodes are placed on subjects hand which measures pulmonary function. Pearson linear correlation coefficient was used for IPFS development and verification PFT. For obtaining FEV1/FVC ratio, evaluation of potential application of IPFS was done. Using DDS (direct digital synthesis) sine wave is injected to both hands of subjects to measure static impedance. During respiration the impedance includes variation in volume and flow of lung impedance. Through improve resolution of IPFS, pulmonary function can be achieved by measuring impedance on patient's hands.[2]

Drawback – Variation in the graphical results as compared to PFT obtained through spirometer.

3 - Asthma Pattern Identification via Continuous Diaphragm Motion Monitoring

In this paper an ultrasound-based system which detects diaphragm movement is used with the implementation of Chan-Vese algorithm.[3]It accurately segment diaphragm area from ultrasound image sequences extracting 1D breathing waveform by computing mutual information (MI) between two consecutive ultrasound frames.

Drawback – difficult to implement ultrasound images of diaphragm movement, time consuming

4- Towards Real-Time Monitoring and Detection of Asthma Symptoms on Resource-Constraint Mobile Device

A system is created using smart phone as platform for data acquisition, analysis and presentation are done with help of embedded intelligence. Patterns correlation done using embedded sensors (digital compass, gyroscope and accelerometer). Microphone records patient's breath sound, ambient data like air pressure, humidity and temperature captured by barometer, hygrometer and thermometer.[4] Evaluating sensors' measurements, severity of patient's condition is being decided.

Drawback – Assumption made only through single symptom Wheezing

2.1 Methodology

In this document I will try to develop a diagnostic tool for the diseases related to the respiratory system which can be identified based on the PFT with spirometer as a sensor.

Spirometer display the following graphs, called spirograms:

a volume-time curve, indicating volume (liters) on the Y-axis and time (seconds) on the X-axis a flow-volume loop, which graphically displays the rate of flow of air on the Y-axis and the total volume of inspired air or expired air on the X-axis. The block diagram of spirometer appears in Fig.

The first block consists of a sensor (spirometer) of gaseous flow followed by differential pressure transducer, a 12 bits A/D converter, and a device including the hardware conditional system and an interface for software development. [10]

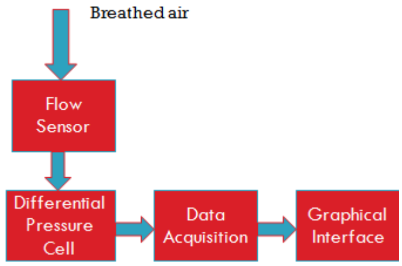

Fig -1: Spirometer structure

2.2 Data Acquisition

Generally, The patient is asked to take the deepest breath as they can, and then exhale into the sensor with a force as hard as possible for at least 6 seconds. If the person is having an upper airway obstruction, the exhalation procedure is quickly followed by a rapid inhalation.

The algorithm designed in software will consist of two programs: the first part is for data acquisition and the second one for data analysis. The applied pressure on the sensor generates the flow vs. time graph. And applying the mathematical integration on the obtained results volume vs. time graph is obtained. Finally the volume vs. flow graph is obtained. The data acquisition portion of the VI reads the voltage data and convert it into the pressure difference values using our calibration equation and then converts the pressure difference to volumetric flow rate (Q) using the theoretical relationship. The VI front panel displays these parameters as well as graphs of the volume data.

2. EXPECTED RESULTS

Information of a spirometric test are:

(1) Graphs of curves volume-time,

(2) Graphs of flow-volume,

(3) Forced Vital Capacity (FVC),

(4) Forced Expiratory Volume in the first second (FEV1);

(5) General information of the patient.

We will develop a graphical representation and interpretation of volume vs. time and flow vs. volume as shown in below figure.

We wish to obtain valid physiological values for PEF, FVC, FEV1, and the ratio between FEV1 and FVC as shown in below table.

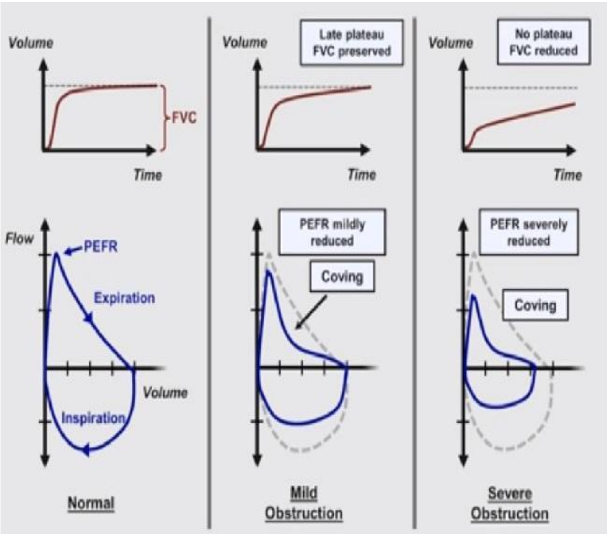

Fig -2: Volume vs. Time & Flow vs. Volume Graph[8]

Subject	PEF(L/sec)	FVC(L)	FEV1/FVC
Average Normal Range	6.0-11.0	3.75-5.5	0.8-0.9
Average Male	5.76	5.33	0.84
Average Female	6.99	4.08	0.92
Obstructive Disease	4.77	6.53	0.61

Table -1: FVC, Peak Expiratory Flow, and FEV1/FVC ratio for each test subject

3. CONCLUSIONS

In this paper, I will propose a real time, non-invasive diagnostic tool for the obstructive disease detection like asthma. The proposed method will generate a volume-time and flow-time curve for several parameters through which extraction of PFT is possible. Based on the obtained graphical representation from the LabVIEW based VI the asthma will be detected. I will try to validate my work with the normal spirometry procedure. In future work, I would like to diagnose restrictive or mixed disease with the same tool.

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