

Spirometry in Telemedicine

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Abstract

Internet has become easily accessible to most people around the world, as pointed out by the PM of Shri. Narendra Modi, prices of data have dropped significantly (at least in India), making India suitable for tele-health. India has a population of 1.3 billion people of which 66.46% of people live in rural areas which means 864 million people live in rural areas. It is almost impossible to give quality medical support to these people in person. This makes telemetry the ideal solution. Most of the lung related diseases causes by environmental factors. The rampant air pollution makes it necessary to keep a constant check on lungs.

Keywords: Spirometry, Lungs, asthma, telemedicine, diagnose, tele-health, COPD

Introduction

Telemedicine is defined as treatment of patients with the help of telecommunication technology. There has been a rapid increase in the usage of telemedicine in the 21st century, it is predicted to grow in the near future. Telehealth provides easy access to patients in rural areas also helps rural hospitals get specialists advice on certain acute cases, this not only helps the patient but also gives an exposure to rural clinicians who on coordinating with specialists become more aware and equipped to treat future patients. Telemedicine increases the number of patients treated by specialist as it an easier and faster way of doing things remote health care aids nursing shortages. ICU's with telehealth facility have seen a significant decrease in mortality rate. The ease of telemedicine gives people a chance to see the doctors more often as it can be done at the comfort of their home, this inturn helps to diagnose progressing health ailments (if any) at its nascent stage thereby giving a better chance in curing the same. Telemedicine also saves money as the trips to the hospitals is decreased significantly. It is also noteworthy that telemedicine would play an important role in increasing productivity- people do not always have to take a day off from work to meet a doctor.

Lungs are arguably the most important organ in the human body but unfortunately its health is often neglected by people all over the world. Most annual full body routine checks do not have a test for lungs. Many places all over the world are experiencing heavy population bursts, which leads to pollution. This means one must keep a constant check on their lungs. Some of the most common lung diseases are COPD (Chronic Obstructive Pulmonary Disease), asthma, emphysema, Pulmonary fibrosis, chronic bronchitis. These diseases are common in all parts of the world and since they don't happen overnight, they are often ignored by people. A simple test can help deduce the presence of these diseases and will help in the treatment. The test mentioned is performed using a device called a spirometer. Since these diseases are chronic (especially asthma) remote advice can be given by a specialist.

Method

Understanding the working of a spirometer

Spirometer is a device used to check functioning of lungs, it is usually a fixed device available only in the bigger hospitals. The advent of digitalization has helped to make these spirometers small and portable.

There are a few types of spirometers:

1. Tank type spirometer/mechanical spirometer- this is the cheapest and the oldest type of spirometer it has a trough that contains liquid and an inverted bell jar which is attached to some weight which in turn is attached to a kymograph.

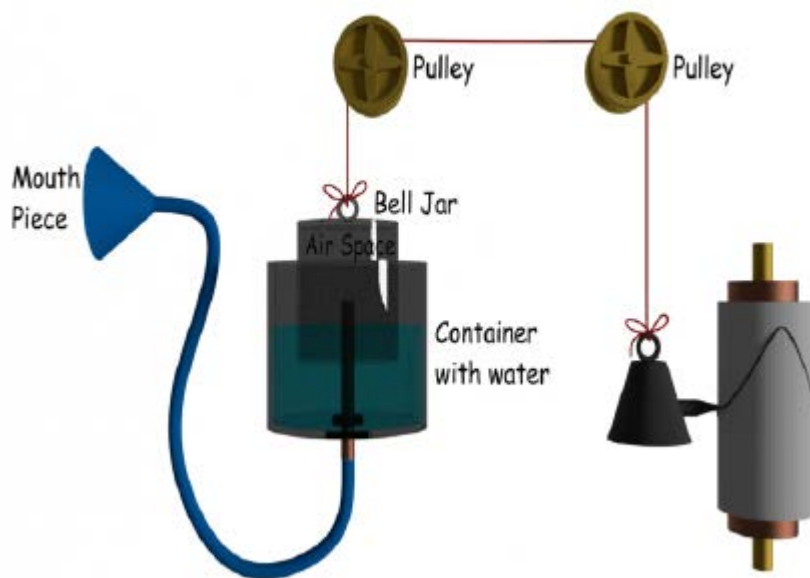


Fig.1- A simple representation of a tank type spirometer

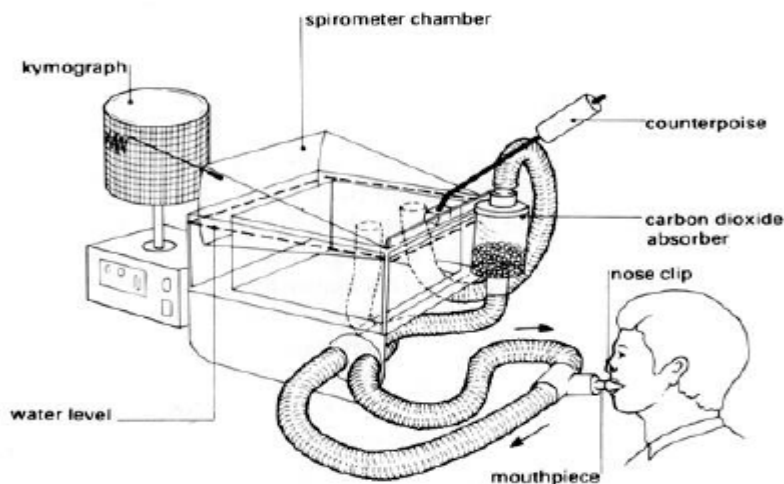


Fig.2- A mechanical spirometer

2. Electronic/ digital spirometer- these devices come in varied sizes, they no more have the old mechanical pulley jar system, and they work with the help of a pressure monitor or a differential pressure sensor. Traditionally there is a pipe or a mouth into which air is blown, differential pressure sensor monitors it and data collected is passed to a microcontroller for further processing.

Spirometer typically measures 2 things:

- Forced vital capacity (FVC). This is the largest amount of air that you can forcefully exhale after breathing in as deeply as you can. A lower than normal FVC reading indicates restricted breathing.
- Forced expiratory volume (FEV 1). This is how much air you can force from your lungs in one second. This reading helps your doctor assess the severity of your breathing problems. Lower FEV-1 readings indicate more significant obstruction.(the number indicates the number of seconds)

Other parameters and terms used include:

- Tidal volume: volume of gas inspired or expired.
- Minute volume: volume of gas exchanged per minute; (tidal volume)* (breathing rate).
- Alveolar ventilation: volume of fresh air entering the lungs; (breathing rate)*(tidal volume- dead space).
- Inspiratory reserve volume: volume of gas inspired during normal respiration.
- Expiratory reserve volume: volume of gas remaining on normal respiration minus that after forced exhalation.
- Residual volume: volume of gas remaining of forced exhalation.
- Vital capacity: maximum volume inhaled after forced exhalation.
- Compliance: change in volume for unit change in pressure.
- Trans-pulmonary pressure: pressure difference between alveolar pressure and intrapleural pressure (in plural cavity, it is slightly less than atmospheric pressure).
- Lung compliance: change in lung volume per unit change in trans pulmonary pressure.
- Chest wall compliance: change in chest wall volume per trans chest wall pressure.
- Static compliance: compliance measured at point of zero airflow.
- Trans airway pressure: pressure gradient across airway and mouth.

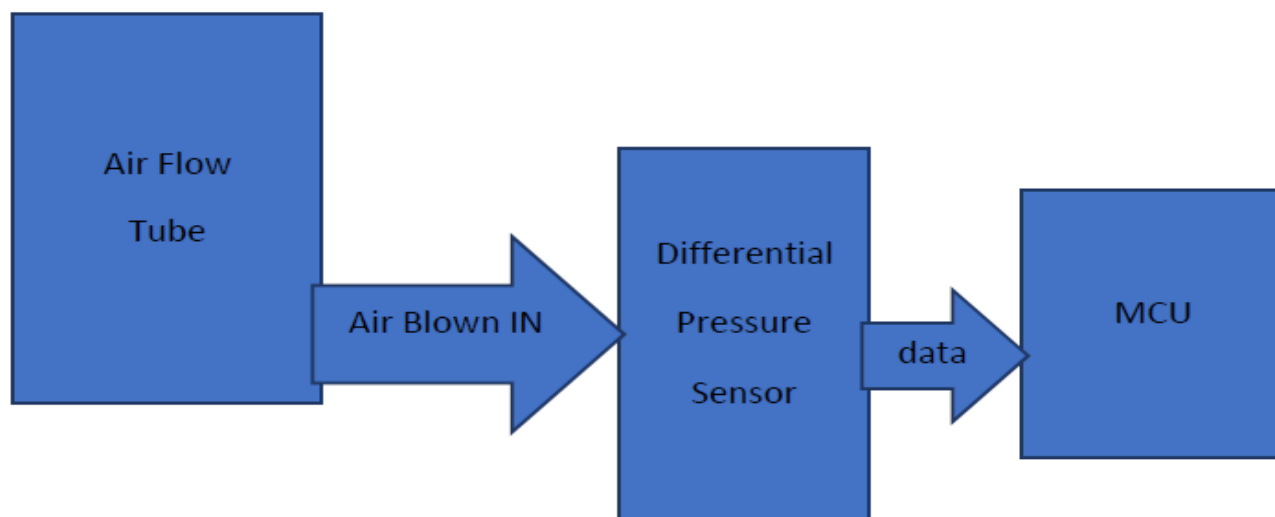


Fig. 3: Digital spirometer block diagram

A telemedical system typically has a transmitter and a receiver at both ends(i.e. the patient's end and the doctor's end).

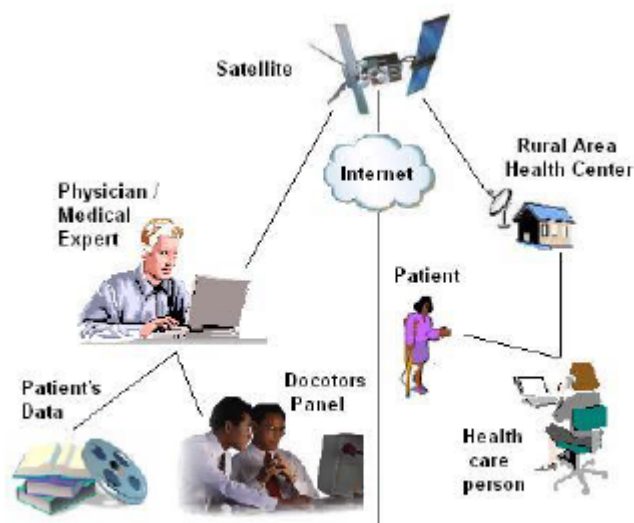


Fig. 4: Telemedical system

The micro controller would be connected to mobile or computer via Bluetooth and the data computed by it would get stored in the cloud under the patient name with a unique id number which could be accessed anywhere in the world. This would not only help the specialist overseeing the patient in another place access it with ease but also creates a permanent record which could be used later if needed.

Algorithm for telemetry-based spirometer:

Lung function test of the subject by a paramedic using a cloud connected spirometer, the acquired signal is processed by a set of hardware and software signal processing modules. This processed signal is displayed on a portable device and is stored in cloud along with the patients age, name, sex, weight and medical conditions of the patient such as diabetes, hyper tension, etc. The stored data is then analysed using AI, Neural networks and fuzzy logic which will indicate the presence of any abnormalities (if any). These results are stored and later validated by specialist doctors. Not only does this give a preliminary report but also aids the doctor as it runs through every disease and there is a chance that specialists may skip looking for a few diseases and thereby reducing human error. this also narrows down the domain of search for the specialist and provides an indication of the patient's condition.

the intelligent system will use artificial intelligence, neural networks and fuzzy logic to determine the presence of any obstructive lung diseases, this would work on the guidelines provided by Global Initiative for Chronic Obstructive Lung Disease (GOLD) and Global Initiative for Asthma (GINA). This will transfer the data to a mobile device which could display the information to the patient as well as the doctor on an application, this application could be customized to every hospital showing their logo.

The application can also have an AI based virtual doctor that could interact with the patient and take into account the symptoms of the patient. This would help in differentiating diseases if they were to have the same reports.

This module can also be used test the severity of a disease that can be detected by the spirometer. algorithm to check for the stage of COPD:

COPD is split into 4 stages based on the effective working of the lungs.

Step1: Calculation of normal results for the given patient, test results from a spirometer test differs from person to person, normal values are calculated with reference to age, sex, race, height and weight.

Step 2: Taking the spirometry test and computing the FEV1 (this is the most important parameter for COPD stage analysis). However the FEV1/FCV values are also considered.

Step 3: If FEV1 reading is greater than 80% of the expected value and FEV1/FVC is less than 70% the patient is said to have very mild COPD, set a random variable “stage” to 1 and goto step 7 else go to step 4.

Step 4: If FEV1 reading is in the range of 50% to 79% of the expected value and FEV1/FVC is less than 70% the patient is said to have very mild COPD, set a random variable “stage” to 2 and go to step 7, else go to step 5.

Step 5: : If FEV1reading is greater than 30% to 49% of the expected value and FEV1/FVC is less than 70% the patient is said to have very mild COPD, set a random variable “stage” to 1 and goto step 7 else go to step6.

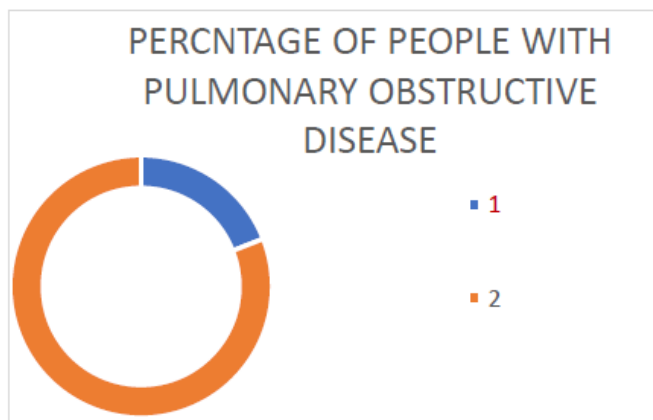
Step 6: If FEV1 reading is greater than 30% of the expected value and FEV1/FVC is less than 70% the patient is said to have very mild COPD, set a random variable “stage” to 1 and goto step 7.

Result and Discussion:

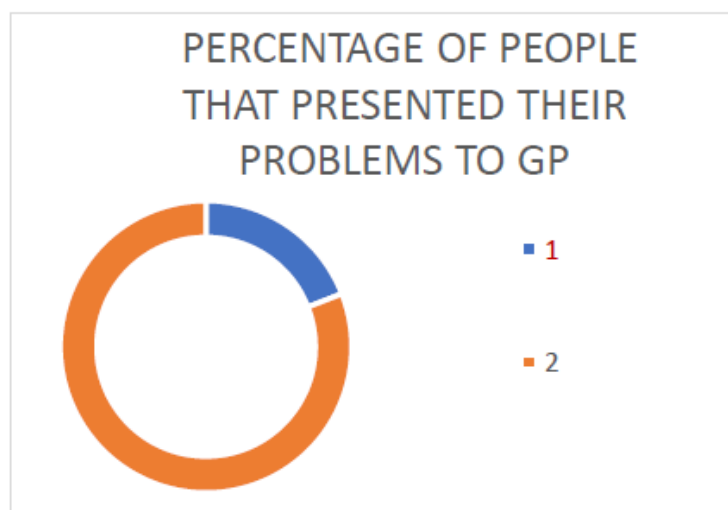
Importance of spirometry in telemedicine

As mentioned earlier lungs are often the most neglected organ on the human body, rural areas in all parts of the world are in desperate need of specialists. There is a high amount of dust and industrial pollution leading to lung related problems, according to a WHO report around 235 million people all around the world suffer from asthma and as many as a 250,000 people die from the same. The major reason is underdiagnosis, this module will help the doctor do the same.

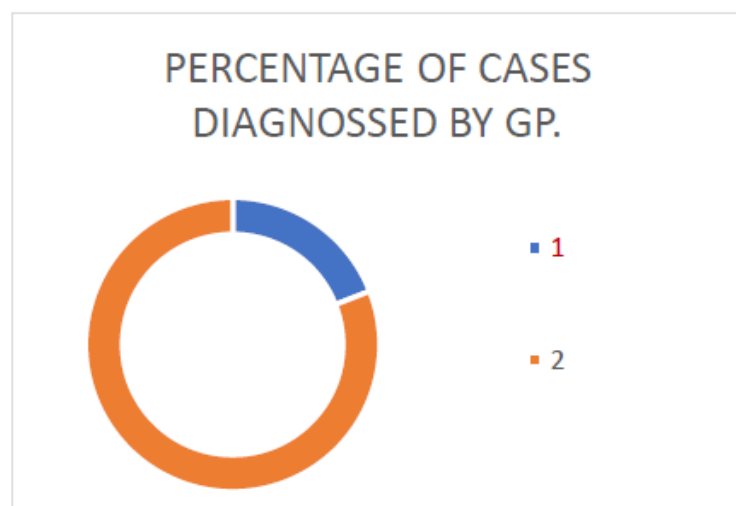
One may question the use of this module and why it is so important for lung-based tests, it should be noted that lung bases chronic diseases do not show up overnight and are easily ignored by the masses. Many sources have shown that underdiagnosis is the main reason for these diseases to go undetected and cause huge issues, if detected early most COPD and asthma patient will have a better quality of life. It is hard to determine the reason behind underdiagnosis, if it is because of the patient’s inability to sense and express the symptoms because FEV1 based. if the doctor overlooks these subtle symptoms. Most of the population visits a GP (general physician) and not a lung specialist because GP’s are easily available and that specialists are hard to find. This module would help aid these problems. According to a paper published by C.P. van Schayck and N.H. Chavannes, it was found that 7% of the test subjects(n=1,150) had pulmonary obstructive diseases, of the 7%, 66% didn’t present their symptoms to the GP, out of those that presented their sickness 21% weren’t diagnosed by the GP.



1-93% of the test subjects with no problem
2-7% of the test subjects with pulmonary obstructive diseases



- 1- Percentage of people that presented their symptoms to the GP(34%).
- 2- Percentage of people that didn't present their problem to the GP(66%).



- 1- Percentage of people that went undiagnosed by GP(21%)
- 2- Percentage of people that were diagnosed(81%)

This meant that out of 86 people detected with lung obstructive diseases 63 went undetected. This clearly means that a semi manned mechanism which gives out fast results are needed, this module would help in doing the same and is a quick, effective and accurate solution.

The number of internet users in India have increased to 560.1 million people, according to telecom Regulatory Authority of India (TRAI) over 1.169 billion active mobile connections as of September 2018 out of which 647.70 million are urban subscribers and 521.59 are rural subscribers this means that there is GSM connectivity in most parts of India. This makes India suitable for telemetry.

Conclusion

This module is very effective and the ease of use will provide employment for semi-skilled workers and it definitely has the potential to save hundreds of thousands of lives, the advances in technology will make the module to be available at very low cost, and since most part of this module is data analysing, it becomes an onetime investment with regular software updates. The mobile nature of the device, and ease of access makes it suitable to use it in health camps anywhere. This module can also provide data about general health status of masses, making it easier for governments to act on the same.

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