Breathing Air Volume and Chest Movement Measuring System for Medical Diagnosis

Major KVP Dhammika (Senior Lecturer Grade II- KDU),Capt J Kumar (Lecturer - KDU), TUO DKR Jayantha (Student), O/Cdt THCJ Somathilaka (Student), O/Cdt MR Koongahawatte(Student)

Abstract

Breathing air volume and rate of a particular person is a key aspect in medical diagnosis. The present equipments used by the contemporary Bio medical technology can only be used when the person is in a good condition. However air volume of unconscious or sleeping patients can't be calculated. The lung capacity may differ from person to person due day to day activities and other habits. This can cause a change in the structure of the lungs and lung capacity.

Proposed breathing air volume measuring equipment is made of a plastic mask, which does not disturb the patient whether he is awake or sleeping. The fan which is fixed on to this mask rotates to side when the patients inhale and other way when he exhales. There's a coil fixed to the fan and magnets fixed in to the mask by the side of the coil. According to the speed of the rotation a forward and backward current will be created and this current is amplified and analyzed by the computer, which is previously calibrated to the related air volume. This will be monitored in the computer and it would be easier for the doctors to identify the illness of a patient according to the breathing air volume.

Chest movements measuring equipment is made of piezo electric strings, and when the chest stretches the piezo electric string will induce a current and this will be measured and analyzed by the computer with previously calibrated values of a healthy person. This device measures both upper chest and lower chest movements, for the doctors to easily examine the patient.

Introduction

Respiratory rate, breathing air volume and chest movement of a patient produce vital information to a physician for correct diagnosis of infirmity. Respiration rate is also known by pulmonary ventilation rate, ventilation rate, or breathing frequency which is the number of breaths taken within a set amount of time, typically 60 seconds. A normal respiratory rate is termed eupnoea; an increased respiratory rate is termed tachypnea and a lower than normal respiratory rate is termed bradypnea. Human respiration rate is measured when a person is at rest and involves counting the number of breaths for one minute by counting how many times the chest rises. Respiration rates may increase with fever, illness, or other medical conditions. When checking respiration, it is important to also note whether a person has any difficulty in breathing.

The physiological and medical norm for respiratory minute ventilation at rest is 6 liters per minute for a 70 kg man [1]. Breathing air volume measuring required to diagnosis many illnesses; Pulmonary Function Testing (PFT) involves a series of breathing maneuvers that measure the airflow and volume of air in lungs. This allows doctor to objectively assess the function of lungs to diagnosis of emphysema. The total volume exhale is called "forced vital capacity," or FVC. The "spirometer" used to measures how much air breathes out during the first second. (This is referred to as "forced expiratory volume in one second," or FEV1.) In general, the faster you breathe out during the first second of a full exhalation.

The chest movement measurements can be used for medical diagnosis in various abnormalities of human body [2]. Our research team conducted research to solve all these tribulations in that we were able to develop a mechanism to induce electrical signal proportionate to inhale and exhale air volume and the pressure. The developed system was interfaced to a computer via a sound card and we were able to measure the electrical signal. From this system we are in the process of obtaining breathing air volume and breathing rate. Further, the team is discovering suitable method to measure chest movement in a most appropriate method to medical diagnosis.

Respiration process

Pulmonary ventilation, or breathing, exchanges gases between the outside air and the alveoli of the lungs. Ventilation, which is mechanical in nature, depends on a difference between the atmospheric air pressure and the pressure in the alveoli. When we expand the lungs to inhale, we increase internal volume and reduce internal pressure. Lung expansion is brought about by two important muscles, the diaphragm and the intercostal muscles. The diaphragm is a dome-shaped sheet of muscle located below the lungs that separates the thoracic and abdominal cavities. When the diaphragm contracts, it moves down. The dome is flattened, and the size of the chest cavity is increased, lowering pressure on the lungs. When the intercostal muscles, which are located between the ribs, contract, the ribs move up and outward. Their action also increases the size of the chest cavity and lowers the pressure on the lungs. By contracting, the diaphragm and intercostal muscles reduce the internal pressure relative to the atmospheric pressure. As a consequence, air rushes into the lungs. When we exhale, the reverse occurs. The diaphragm relaxes, and its dome curves up into the chest cavity, while the intercostal muscles relax and bring the ribs down and inward. The diminished size of the chest cavity increases the pressure in the lungs, thereby forcing out the air.

Average resting respiratory rates by age:

Birth to 6 weeks	:	30-60 breaths per minute
6 months	:	25-40 breaths per minute
3 year	:	20-30 breaths per minute
6 years	:	18-25 breaths per minute
10 years	:	15-20 breaths per minute
Adults	:	12-20 breaths per minute

The Respiratory System Important Terminologies

The respiratory system consists of all structures which are used in the process of breathing and supplying our bodies with Oxygen. This is the path that air takes when we breathe it in. The body uses Oxygen and creates waste Carbon Dioxide because of the volumes of both gases in the air we breathe in and out:

Inspiration

In order to draw air into our lungs, the volume of the chest or thoracic cavity must increase. This occurs because the Intercostal muscles and the diaphragm contract. The rib cage moves up and out and the diaphragm flattens to increase the space. This decreases the air pressure within our lungs, causing air to rush in from outside.

Expiration

At the end of a breath, the intercostal muscles and diaphragm relax, returning to their starting position, which decreases the size of the thoracic cavity. The decreased space and increased air pressure in the lungs forces air out.

Lung Capacity

Our lungs can hold varying amounts of air, depending on how deeply and quickly we breathe. They are also never empty, even if you breathe out as far as you can. Here are some terms used to describe some of these volumes:

Tidal volume

The amount of air you breathe in or out with each breath.

Inspiratory capacity

The maximum amount you can breathe in (after a normal breath out).

Expiratory reserve volume

After breathing out normally, this is the extra amount you can breathe out.

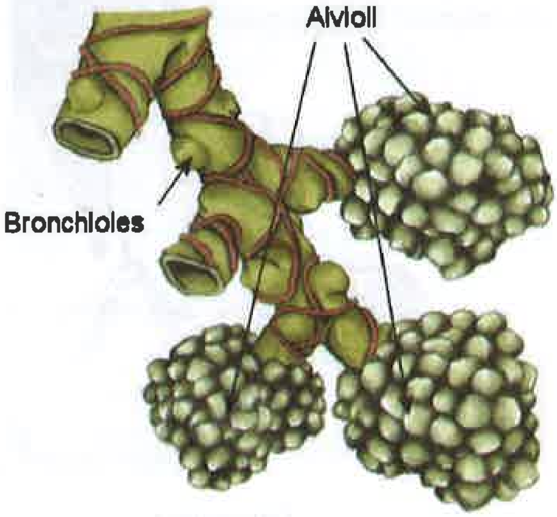
Vital capacity

The maximum amount of air you could possibly breathe in or out in one breath.

Residual volume

The amount of air left in your lungs after you have breathed out as much as possible. As we exercise, our need for Oxygen increases. This means that the amount we breathe in and pump around our bodies in the blood must change to keep up. To achieve this, we breathe faster and our heart pumps faster.

This increased oxygen uptake, is measure by your VO_2, or the amount of oxygen your body uses in a minute. This can be used as a prediction of your fitness level. The maximum VO_2 is called **VO_2 Max** and the fitter you are the higher this is because your body is more effective at taking in and using oxygen.



Diagnosis of illnesses using breathing air volume

Doctors calculate patients' lung capacities to determine their pulmonary health. Several diseases reduce the lungs' volume, including pneumothorax and pulmonary fibrosis. Other diseases, such as chronic obstructive pulmonary disorder and asthma, obstruct air flow [2].

Requirement of the equipment

The equipment in current use for the measurement of breathing air volume is called spirometer. But to use this equipment the patient should be in a conscious mode because the patient has to blow air by force in to the equipment

So the patient who is sleeping or unconscious is unable to use this equipment, in that case we are going to introduce this new equipment which can be used to measure the air volume of breathing even though the patient is sleeping or unconscious. Physicians use an instrument called a spirometer to measure the tidal volume, that is, the amount of air we exchange during a ventilation cycle. Under normal circumstances, we inhale and exhale about 500 ml, or about a pint, of air in each cycle. Only about 350 ml of the tidal volume reaches the alveoli. The rest of the air remains in the respiratory tract. With a deep breath, we can take in an additional 3,000 ml (3 liters or a little more than 6 pints) of air. The total lung capacity is about 6 liters on average. The largest volume of air that can be ventilated is referred to as the vital capacity. Trained athletes have a high vital capacity. Regardless of the volume of air ventilated, the lung always retains about 1,200 ml (3 pints) of air. This residual volume of air keeps the alveoli and bronchioles partially filled at all times.

Spirometer

A healthy adult ventilates about 12 times per minute, but this rate changes with exercise and other factors. The basic breathing rate is controlled by breathing centers in the medulla and the pons in the brain. Nerves from the breathing centers conduct impulses to the diaphragm and intercostal muscles, stimulating them to contract or relax. There is an inspiratory center for inhaling and an expiratory center for exhaling in the medulla. Before we inhale, the inspiratory center becomes activated. It sends impulses to the breathing muscles. The muscles contract and we inhale. Impulses from a breathing center in the pons turn off the inspiratory center before the lungs get too full. A second breathing center in the pons stimulates the inspiratory center to prolong inhaling when needed. During normal quiet breathing, we exhale passively as the lungs recoil and the muscles relax. For rapid and deep breathing, however, the expiratory center becomes active and sends impulses to the muscles to bring on forced exhalations.

The normal breathing rate changes to match the body's needs. We can consciously control how fast and deeply we breathe. We can even stop breathing for a short while. This occurs because the cerebral cortex has connections to the breathing centers and can override their control. Voluntary control of breathing allows us to avoid breathing in water or harmful chemicals for brief periods of time. We cannot, however, consciously stop breathing for a prolonged period. A buildup of carbon dioxide and hydrogen ions in the bloodstream stimulates the breathing centers to become active no matter what we want to do.

Introducing Methodology

The equipment we introduce is consisting of a typical oxygen mask which seals the nose and mouth of the patient, A small fan, is fixed to the air flowing tube. The fan is made of light metal which is rotating even for a slightest breathing air flow. Fan shaft is fitted with a small magna A small copper coil is wound around the portion of tube underneath of the magnet. Due to the air pressure the fan rotates cutting the magnetic flux which helps to generate small electric currents that will be consequently amplified to a certain level where we can monitor it using an oscilloscope. The fan is designed especially considering its light weight and covering the total area of the air flowing tube.

A tachometer circuit is used to measure the rpm of the fan. The rpm of the fan can be directly converted in to the air volume by an equation. Air velocity is calculated by dividing the volumetric flow rate by the cross-sectional area of the air flow passage.

$$Velocity(m/s) = Volume(m^3/s)/area(m^2)$$

And

The RPM to Linear Velocity formula is :

$$v = r \times RPM \times 0.10472$$

Where:

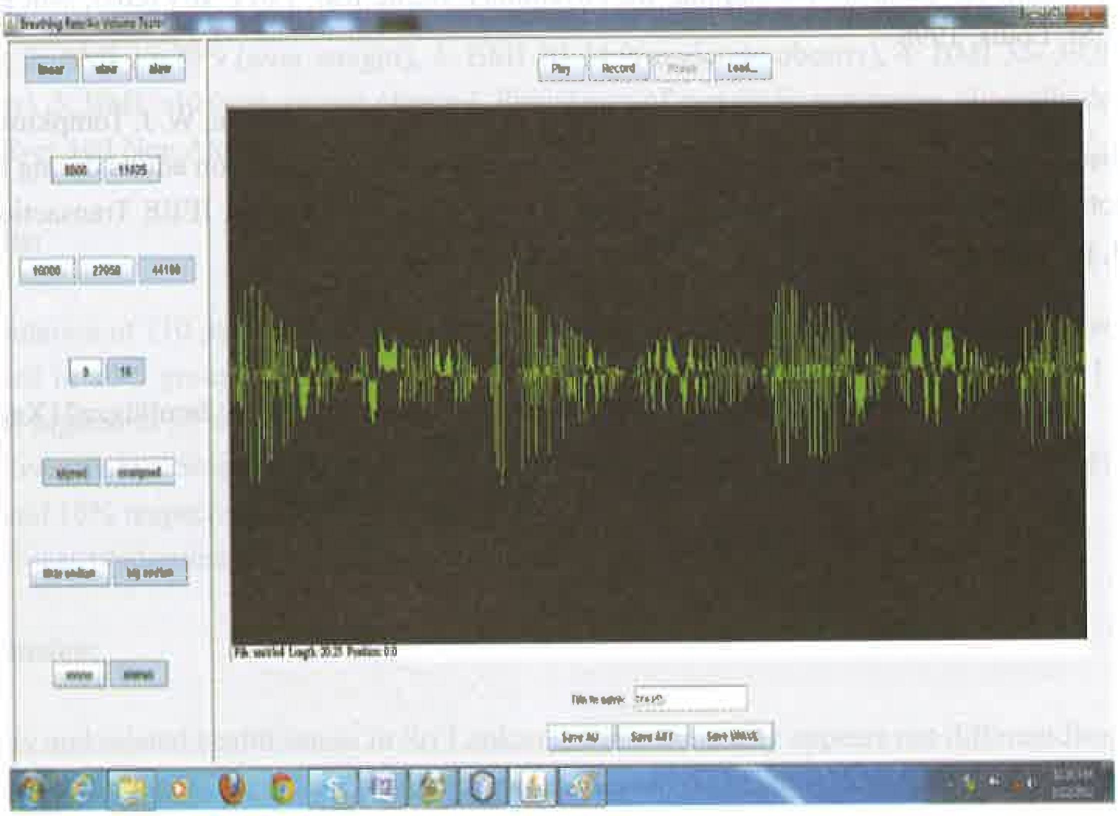
v = Linear velocity, in m/s

r = Radius, in m

RPM = Angular velocity, in RPM (Rounds per Minute)

Data Acquisition

Electrical signals are generated using a fan fed to a computer via sound card. That particular real time analog signal is converted to a digital signal at the sound card and it measures frequency



and amplitude of a one breath which is proportionate to the air volume passed through the fans. Project team planned to calibrate the system using two methods One is in relation to Spirometer and other one is pumping known air value to a balloon and letting it pass through a developed system and averaging.

We developed a software which can graphically represent breathing pattern and volume in computer monitor Further we are in a position to store this information in a computer for retrieval and further investigation.

Future Work

We are in a process of gather breathing patterns of normal persons and persons who are unwell and creating a data base for referencing and automatically comparing breathing patterns to diagnose the possible infirmity of one's breathing pattern. Further validation of the equipment is yet to be complete. Planning to miniaturize the equipment by coupling acquired electrical signals to a microcontroller and display via small LCD. Designing of chest movement detection equipment is going to be our next challenge and we are planning to develop it using digital image processing technique and using pieso electric materials.

Conclusion

We believe our product will serve to the human kind in numerous ways especially in medical diagnosis. Our efforts to achieve this goal will persistence till we reached to it.

References

[1] Castro M. Control of breathing. In: Physiology, Berne RM, Levy MN (eds), 4-th edition, Mosby, St. Louis, 1998.

[2] K. P. Cohen, W. M. Ladd, D. M. Beams, W. S. Sheers, R. G. Radwin, W. J. Tompkins and J. G. Webster, "Comparison of impedance and inductance ventilation sensors on adults during breathing, motion, and simulated airway obstruction," Biomedical Engineering, IEEE Transactions on, vol. 44, pp. 555-566, July. 1997.

[3] http://www.teachpe.com

[4] http://www.ehow.com/how_7422491_calculate-volume-air-patient.html#ixzz21XaZ6gbt