CHRONOLOGY OF SPIROMETER – A REVIEW

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ABSTRACT:

A spirometer is an apparatus for measuring the volume of air inspired and expired by the lungs. A spirometer measures ventilation, the movement of air into and out of the lungs. The spirogram will identify two different types of abnormal ventilation patterns, obstructive and restrictive. There are various types of spirometers which use a number of different methods for measurement (pressure transducers, ultrasonic, water gauge).

One of the important tests of lung function is measuring lung volume using spirometer. Most of us are not aware of origin of this commonly performed test. This review trace the development of spirometry from past till the present year.

KEYWORDS: spirometer, spirometry, lung function test.

INTRODUCTION:

Spirometer is a device used to measure the breath. It is the common device used for measuring lung function. Spirometry measures the amount (volume) and/or speed (flow) of air that can be inhaled and exhaled. Spirometry is invaluable as a screening test of general respiratory health. The most important aspects of spirometry are the forced vital capacity (FVC), the forced expiratory volume (FEV) in one second (5). It also helps in measuring several other readings like FEV1%FVC, PEF, FET. Spirometry is an important tool used for generating pneumotachographs, which are helpful in evaluating conditions such as asthma, pulmonary fibrosis, cystic fibrosis, and COPD (1,3&9).

HISTORY OF SPIROMETER:

The earliest known history of spirometry, during 129 – 200 AD, Claudius Galen, performed a volumetric experiment on human respiration. He had a boy respire in and out of a bladder and described that after a period of time, the volume of gas remains same. This was a simple
experiment that explained by Claudius. Around 1681, Giovanni Alfonso Borelli tried to measure the volume of air breathe in one breath by sucking a liquid up a tube and measuring the displaced volume. One thing he did that is still performed today is to block off the nostrils to make sure that no air escapes through the nose while trying to measure the air that enters and leaves the oral cavity. Today they gently clip the nose with clips similar to clothespins. This became the very beginning of the spirometer. In the early 1700's, J. Jurin recorded the absolute measurements of air volume by experimenting blowing into a bladder. And by using the principles of Archimedes, he was able to evaluate the air volume in the bladder. Later in the 1800's, there were many more complex devices was developed and experiments were performed for finding the vital volume of lung and other important parameters. In 1813, Kentish E. made a major step in the history of spirometer. He invented the device "Pulmometer", which is peculiarly graduated bell-like jar placed in water. Soon after Sir Humphry Davy used a gasometer to assess various volumes and capacities. The gasometer he used was "a complex instrument with an ingenious counterweight used to balance the increased weight of the gasometer when the gas enters from the silk bag... [He] would have used the bag to collect expired air". Davy's measurements of oxygen consumption and carbon dioxide production are a huge contribution to spirometry because doctors and exercise physiologists had confidence to greater extent on them. By the 1840's, John Hutchinson, a surgeon, officially invented the spirometer (see diagram below). It measured vital capacity, which he believed to be a powerful indicator of longevity. His spirometer consisted of a bell inverted in water which is calibrated, which captured expired air from the lungs [2]. With some modifications, Hutchinson's water spirometer is still used today. Modifications made are the reduction of the mass of the bell, the addition of graphic, timing devices and several new measuring parameters were introduced (7, 16&17).

Modification of spirometer

After Dr. Hutchinson's invention, there were many modifications that were made to make it easier to use. In 1859, E. Smith developed a portable spirometer, on which he measured gas metabolism. In the 1920's, H.W. Knipping and Brauer introduced ergospirometry. Now a days easy portable spirometers are made such as laptop based, Ipad based and mobile based spirometers are developed and used (7).
TYPES OF SPIROMETER:

• Whole body plethysmograph:
This type of spirometer gives a more accurate measurement for the components of lung volumes as compared to other conventional spirometers. A person is enclosed in a small space when the measurement is taken (11).

• Pneumotachometer:
This spirometer measures the flow rate of gases by detecting pressure differences across the fine mesh. One advantage of this spirometer is that the subject under investigation can breathe in fresh air during the experiment (12).

• Fully electronic spirometer
Electronic spirometers have been developed that compute airflow rates in a channel without the need for fine meshes or moving parts. They operate by measuring the speed of the airflow with techniques such as ultrasonic transducers, or by measuring pressure difference in the channel. These spirometers have greater accuracy by eliminating the momentum and resistance errors associated with moving parts such as windmills or flow valves for flow measurement. They also allow improved hygiene between patients by allowing fully disposable air flow channels.

• Incentive spirometer
This spirometer is specially designed to improve one's functioning of the lungs (13).

• Peak flow meter
This device is useful for measuring the ability of a person breathing out air (14).

• Windmill-type spirometer
Used specially for measuring forced vital capacity without using water and has broad measurements ranging from 1000 ml to 7000 ml. It is more portable and lighter as compared to traditional water-tank type spirometer. This spirometer should be held horizontally while taking measurements because of the presence of rotating disc.

- Tilt-compensated spirometer

Tilt-compensated type spirometer also known as the AME Spirometer EVOLVE. This new spirometer can be held horizontally while taking measurements but should the patient lean too far forward or backwards the spirometer's 3D-tilt sensing compensates and indicates the patient position (15).

**Indications for performing spirometry:** (10)
Spirometry has a variety of uses including:

- assisting with diagnostic evaluations
- monitoring of pulmonary function
- evaluating disability or impairment

**Contraindications for performing spirometry:** (10)
Some conditions may pose a relative danger to a patient or affect the validity of spirometry performance and results. These include, but are not limited to the following:

- unstable cardiovascular status, unstable angina, recent myocardial infarction (within one month), or pulmonary embolism
- haemoptysis of unknown origin
- recent pneumothorax
- thoracic, abdominal, or cerebral aneurysms
- recent thoracic, abdominal or eye surgery
- acute disorders such as nausea or vomiting
- severe respiratory distress
- physical limitations
- cognitive impairment, dementia
- inability to adequately understand and follow instructions

**MEASUREMENTS FOUND:**

- **VC** Vital capacity, litres (L)
- **IVC** Inspiratory vital capacity, litres (L)
**FINDINGS:**

Deviation from normal spirometry readings can be said as two types

- Obstructive lung diseases
  (Or)
- Restrictive chest diseases.

**Obstructive lung disease** is a category of respiratory disease characterized by airway obstruction. It is generally characterized by inflamed and easily collapsible airways, obstruction to airflow, problems exhaling and frequent medical clinic visits and hospitalizations (18).

Types of obstructive lung disease include:

- asthma,
- bronchiectasis,
- bronchitis and
- Chronic obstructive pulmonary disease (COPD).

**Restrictive lung diseases** are a category of extra pulmonary, pleural, or parenchymal respiratory diseases that restrict lung expansion, resulting in a decreased lung volume, an increased work of breathing, and inadequate ventilation and/or oxygenation. Pulmonary function test demonstrates a decrease in the forced vital capacity (19).

**Normal FEV\(_{1.0}\) and FVC curve:**

\[
\text{FEV}_{1.0}\text{FVC} \times 100 > 80\%
\]

T - Time taken for complete expiration

**In case Obstructive airways disease:**

\[
\text{FVC, FEV}_{1.0}\% \text{ is found to be decreased in this disease}
\]

**In case of restrictive chest disease**

FVC is found to be decreased, FEV\(_{1.0}\)% is found to be normal in this disease.
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