

John Hutchinson, a surgeon, recognized that the volume of air that can be exhaled from fully inflated lungs is a powerful indicator of longevity. He invented the spirometer to measure what he called the vital capacity, ie, the capacity to live. Much later, the concept of the timed vital capacity, which became known as the FEV₁ was added. Together, these two numbers, vital capacity and FEV₁, are useful in identifying patients at risk of many diseases, including COPD, lung cancer, heart attack, stroke, and all-cause mortality. This article cites some of the rich history of the development of spirometry, and explores some of the barriers to the widespread application of simple spirometry in the offices of primary care physicians.

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Abbreviations: FEV₁ = forced expiratory volume in 1 s; NLHHP = National Lung Health Education Program

John Hutchinson, a surgeon, invented a calibrated bell, inverted in water, in order to be able to capture and measure the volume of exhaled air from fully inflated lungs. He coined the term *vital capacity*, ie, the capacity for life, because he realized that compromise of this crucial measurement was predictive of premature mortality. His exacting observations taught him that in normal subjects, the vital capacity was directly related to the height, and inversely related to the age of the individual. Weight had only a minor effect on the vital capacity, but he observed that vital capacity became mildly reduced following a large meal.¹ In his first article published in 1846, he reported on measurement of 2,130 individuals, including deceased patients (Table 1). Hutchinson would go to the morgue immediately following death, insert into the trachea the equivalent of an endotracheal tube with a stopcock, and inflate the corpse with a bellows until no more air could enter. He then released the flow of air into his spirometer by opening the stopcock. The lungs and thorax emptied through elastic recoil. Of course, this was not the full FVC, but something very close to it. The lungs emptied to their minimum volume, a function of the residual volume. In this era, tuberculosis was rampant in Europe. Hutchinson recognized that fibrotic complications from tuberculosis resulted in a reduced vital capacity and early death. Similar observations were made in heart failure and in coal miners.²

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of London. He believed that the vital capacity should be used in actuarial predictions for persons selling life insurance. Hutchinson's invention was initially acclaimed:

...we have no hesitation in recording our deliberate opinion, that it forms one of the most valuable contributions to physiologic science that we have met with for some time. In all future investigations into the phenomena of the respiratory process, the name of Mr. Hutchinson must receive honorable notice.³

Hutchinson's instrument (Fig 2) was not widely accepted in London, or anywhere else, and still remains absent from most physicians' offices and clinics. This may be one of the reasons why John Hutchinson was frustrated when he left his wife and three children and emigrated to Melbourne, Australia at 41 years of age.^{2,5}

He may have been in search of gold, since a gold strike had just been made in Australia. Another speculation is that he had tuberculosis and sought the cure of a prolonged ocean voyage with abundance of fresh air and sunshine, which was a common method of seeking the cure for tuberculosis in that era.³ Other speculations over alcohol abuse were made.¹ After he reached Australia, he abandoned all further use of his spirometer. Toward the end of his life he moved to Fiji, where he died at 50 years of age, probably a victim of murder.² His autopsy showed no signs of tuberculosis, nor did it explain his demise.⁶ No evidence of liver disease was found at autopsy.¹

A statue was erected to the memory of John Hutchinson by the Thoracic Society of Australia and the British Thoracic Association in 1990 (Fig 3). It can be viewed by visitors to Fiji.

VITAL CAPACITY AS A PREDICTOR OF HEART DISEASE

In 1980, the Framingham Study of 5,209 men over the age of 30 years reported that the vital capacity was a powerful prognostic indicator⁶:

This simple office procedure is a useful predictor of pulmonary disease and cardiac failure and can effectively select groups of persons destined for premature death. Since the FVC predicts cardiovascular as well as noncardiovascular mortality this pulmonary function measurement seems truly a measure of living capacity useful for insurance and underwriting purposes.⁶

However, to this day, even large insurance policies do not require spirometry to identify persons at high risk of premature mortality.

BARRIERS TO WIDESPREAD APPLICATIONS

If the vital capacity is so important to clinical medicine, why don't all physicians have spirometers in their offices just as they have the chest radiograph (introduced into medicine in 1895), the sphygmomanometer (invented in 1896 or an ECG machine (invented in 1903)? Could it be that pulmonologists and physiologists who established

Sailors (merchant service)	121
Fire Brigade of London	82
Metropolitan Police	144
Thames Police	76
Paupers	129
Mixed class (artisans)	370
First Battalion Grenadier Guards	87
Royal Horse Guards (Blue)	59
Chatham recruits	185
Woolwich Marines	573
Pugilists and wrestlers	24
Giants and dwarfs	4
Printers	73
Dravmen	20
Girls	26
Gentlemen	97
Diseased cases	60
Total	2,130

*Adapted from Hutchinson.'

pulmonary function laboratories clouded their instrument in mystery, so as to obscure the true value of spirometry in primary care medicine? If so, "we have found the enemy, and he is us!" (borrowed from the comic strip, Pogo).

There is absolutely nothing that is complicated about spirometry. Spirometry measures airflow from fully inflated lungs over time in liters, as described by Hutchinson. Tifineau added a second measurement, the FEV₁, working at the Hotel Dieu in Paris, in 1947.- Thus, the FVC is the amount of air exhaled from fully inflated lungs, and FEV₁ measures airflow during the first part of the vital capacity maneuver."

THE ESSENCE OF SPIROMETRY

Spirometry is a simple expression of a complex process, just like BP. When the lungs are filled, they and the thorax are stretched to the maximum. Following a forced expiration, the lungs empty down to the residual volume, leaving a small amount of air in the upper portions of the lung, (Fig 4). This is because the upper lung has less elastic recoil than the lower part of the lung. The spirogram reflects the muscular effort to start the process, elastic recoil of lungs and thorax, small airways function, large airways function, and the interdependence between airways and alveoli. Small airways and alveoli are interconnected by an elastic infrastructure that matches ventilation and circulatory distribution throughout the lung in an exquisitely orchestrated process.

Some insight may be gained into the mystery of the slow acceptance of spirometry into the practice of medicine by the following quotations offered by two highly respected pulmonary physiologists. Doctors Peter Jacklem, and Solbert Permutt.

"It is likely that in every case of significant chronic airflow limitation, there was a time in the past history of the patient when airflow limitation was minimal, and that the development of chronic airflow limitation from that earlier time is an insidious process:"

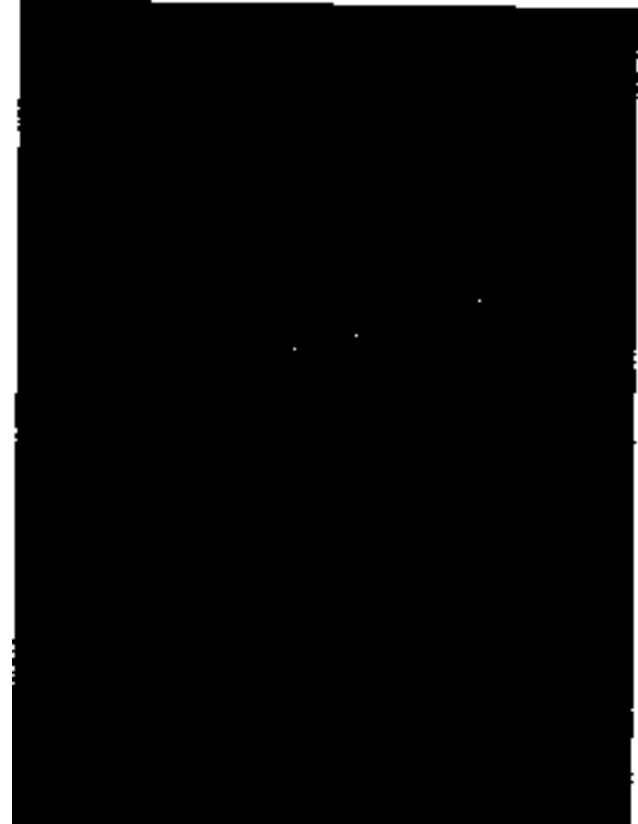


FIGURE 1. John Hutchinson, 1811-1861, inventor of the spirometer. Reprinted with permission from Wellcome Trust Medical Photographic Library.

They also wrote,

In considering the simplicity of determination of FEV₁ and its potential use in detecting individuals who are headed toward serious trouble at a time when intervention might prevent a disastrous outcome, it is interesting to explore the reasons why the spirometer has not achieved a position comparable to the clinical thermometer, the sphygmomanometer, the ophthalmoscope, the chest radiograph, and the ECG ...

and perhaps one of their most profound comments is,

"Perhaps even greater responsibility for the near absence of the use of pulmonary function in the prevention of chronic airflow limitation must be borne by the expert in pulmonary medicine, and especially in his relation to the nonspecialist."

Spirometry has many applications and is an excellent predictor of prognosis in all stages of COPD. It is necessary to evaluate responses to therapy. Abnormal spirometry also predicts death from heart attack a fourfold to sixfold higher risk of lung cancer than if airflow is normal and all cause mortality. So, why is spirometry so slow to be accepted? It is estimated that only 20 to 30%

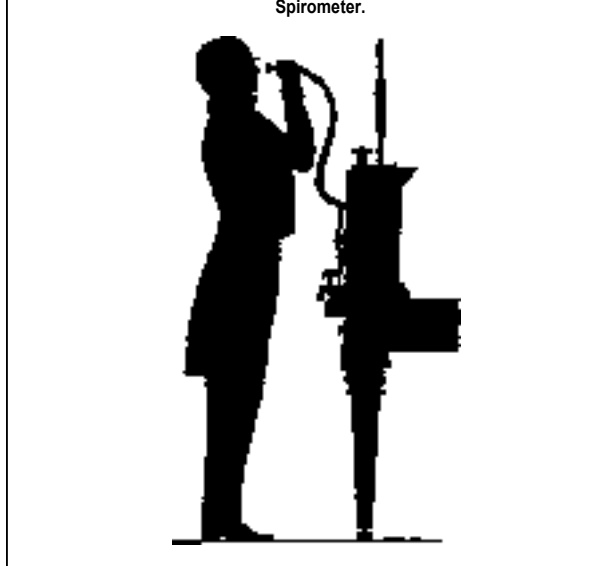


FIGURE 2. Silhouette of John Hutchinson and his spirometer, illustrating correct body positioning for performance of the vital capacity maneuver. Reprinted with permission from *The Lancet*.

of primary care physicians actually have a spirometer in their office, or regularly use spirometry in their practice.

FOUNDATIONS FOR COPD SCREENING

The third National Health and Nutrition Examination Survey, which looked at a random population of > 20,000 Americans, shows a high prevalence of undiagnosed and untreated COPD, which increases with age. This study of

respiratory symptoms of classic cough and dyspnea.²¹ An earlier study of smokers with only mild airflow obstruction, the Lung Health Study, revealed a high prevalence of lung cancer (the most common cause of death in a 5-year follow-up), heart attack, and stroke.

Both the Lung Health Study²² and third National Health and Nutrition Examination Survey are the foundations for a new health-care initiative, the National Lung Health Education Program (NLHEP).²³ "Test your lungs, know your numbers" is the motto of the NLHEP. The NLHEP recommends testing all smokers > 45 years old, and anyone with cough, shortness of breath, or wheeze.²⁴ The NLHEP consensus committee recommends use of forced expiratory volume in 6 s (FEV₆), as a surrogate for FVC. Normal lungs empty in six seconds. The FEV₆ is an easier test for patients, and has been shown to be a good indicator of both obstructive and restrictive ventilatory disorders.²⁵ Fortunately, industry has developed modern spirometers, simple, accurate, handheld devices that report key values (FEV₁/FEV₆ and FEV₁/FVC). The software of new devices monitors the fidelity of the 6-s expiration and gives a visual indication of the quality of the spirogram.

Clinical interpretations of normal and the degree of obstructive and restrictive abnormalities are displayed. The volume/time and flow/volume expiration curves can be recorded by interface with the spirometer with a standard printer to produce hard copy.

POPULARITY OF THE SPHYGMOMANOMETER

Contrast the history of spirometry with that of the development and widespread application of the sphygmom-

TO THE MEMORY OF JOHN HUTCHINSON M.D.

THE MENTOR OF THE SPIROMETER
AND A MAN OF RESPIRATOR

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PRACTISED MEDICINE ■ LOUD= TO 1SS2
AROUND AUSTRALIA

DIED LEYUKA, FIJI 18 JULY 1881

ERECTED BY
THE THORACIC SOCIETY OF AUSTRALIA
AND
THE BRITISH THORACIC ASSOCIATION

1980

FIGURE 3. A statue was erected to the memory of John Hutchinson by the Thoracic Society of Australia and the British Thoracic Association in 1980. It can be viewed by visitors to Fiji.

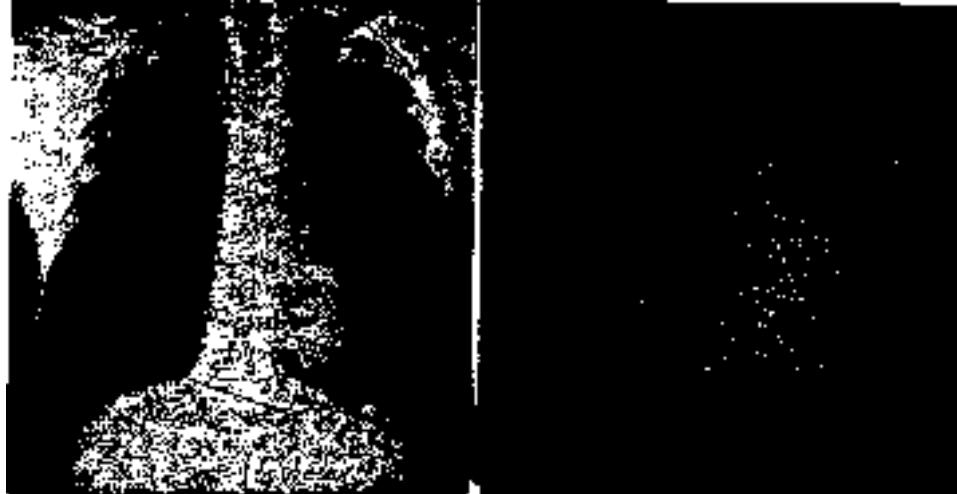


FIGURE 4. Following a forced expiration, the lungs empty down to the residual volume, leaving a small amount of air in the upper portions of the lung.

manometer, invented 50 years after the spirometer. The cuff sphygmomanometer was invented by Italian physician Scipione Riva-Rocci in 1896. This simple device caught the eye of US surgeon Harvey Cushing, who believed he could use it in the measurement of BP, which would be useful in his ongoing studies of cerebral perfusion. Cushing introduced this instrument at Johns Hopkins Hospital. Early supporters of this new method of BP measurements were Theodore Janeway in New York City and George Crile in Cleveland, OH. After only 2 years of experience on the wards of Johns Hopkins Hospital, Cushing and his surgical house officers set out to promote wider use of the cuff. This was the foundation for the use of BP measurements in epidemiologic studies and for controlled clinical trials of antihypertensive agents, which have so dramatically reduced the socioeconomic impact of heart attack and stroke in the last 25 years.¹⁸ Perhaps the same may still happen with spirometry, but progress has been painfully slow.

Today, > 200,000 primary care physicians see the vast majority of smokers in their offices at least once a year, and others with diseases characterized by premature morbidity and mortality. The vital capacity and the FEN₁ must emerge as important as BP, cholesterol tests, and other indicators of incipient disease states to alert physicians and the patients that they serve to the importance of early treatment for COPD and related disorders.

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