

The stethoscope

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Stetho•scope

Pronunciation: 'steth-ə-ɪskəpō also 'steth-

Function: noun

: an instrument used to detect and study sounds produced in the body that are conveyed to the ears of the listener through rubber tubing connected with a usually cup-shaped piece placed upon the area to be examined

- **stetho•scop•ic** / 'steth-ə-'skäp-ik also 'steth- / adjective

- **stetho•scop•i•cal•ly** /-i-k (ə-) lē / *adverb*¹

Key words

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History

'I recalled a well known acoustic phenomenon: if you place your ear against one end of a wood beam, the scratch of a pin at the other end is distinctly audible. It occurred to me that this physical property might serve a useful purpose in the case I was dealing with. I then tightly rolled a sheet of paper, one end of which I placed over the precordium and my ear to the other. I was surprised and elated to hear the beating of her heart with far greater clearness than I ever had with direct application of my ear. I immediately saw that this might become an indispensable method for studying not only the beating of the heart, but all the movements able of producing sound in the chest cavity.'

This is a transcription of how Dr. Rene Theophile Hyacinthe Laënnec came to invent the most basic of stethoscopes. He had been asked to see a young woman with 'generalized symptoms of a diseased heart'.² In an age where a lot of patients were too obese for sounds to be heard by immediate auscultation (i.e. applying one's ear to the patient's chest), where washing was not a social norm, where some patients were infested with vermin, and modesty was an issue, he had to find an alternative to immediate auscultation...

After 3 years of testing various materials with which to make tubes, perfecting his design and listening to the chests of people with pneumonia, he came up with a hollow tube of wood, 3.5cm in diameter and 25cm long.³ (Figure 1,2) Following years of trials and tribulations, he presented his findings and research on the stethoscope to the Academy of Sciences in Paris in 1818; in 1819 he published his masterpiece, *De l'auscultation médiate ou Traité du Diagnostic des Maladies des Poumons et du Coeur*.

It is interesting to note that before Laënnec, auscultation was not widely practiced, even though Hippocrates had mentioned the succussion splash in the chest and in 1628, William Harvey stated: 'There is a beating within the breast'. It was not until 1761 that Leopold Auenbrügger, a Viennese physician, described the technique of percussion to detect pleural effusions, having adapted this from observing his father, an innkeeper, tapping a wine barrel to see if it was empty or full.⁴

The monaural stethoscope was initially regarded with suspicion and was described by an American doctor as 'the objectionable European instrument'. Remarkably, one might say, it underwent various modifications for nearly a century; in fact a 1912 catalogue showed 78 monaural types as opposed to 53 binaural.⁵

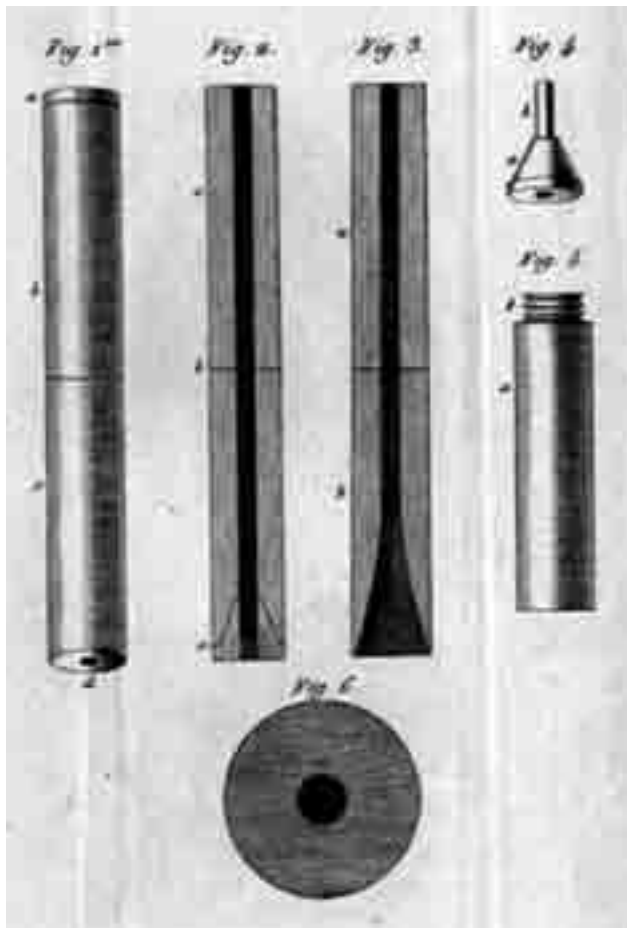


Figure 1: A design showing Laënnec's stethoscope

In 1829, CJB Williams made a binaural stethoscope, using a couple of bent lead tubes, and a lack of availability of materials flexible enough to be used as tubing stalled the evolution of the binaural. CW Pennock, an American made a binaural with flexible brass tubing in 1844, while others used caoutchouc for the tubing, which consisted of woven silk impregnated with unrefined rubber. Dr Leared, in 1851, at the Great International Exhibition, produced one of gutta percha (percha rubber).

In 1884, ET Aydon Smith described what he called 'the ultimate instrument', one that could be used as a monaural, binaural, or differential stethoscope, an otoscope (by using the chest piece), and the tubing could be used as an enema or oesophageal tube, a catheter or even as a tourniquet.⁶

George Cammann produced a cost-effective design, one similar to 20th century models, in 1856, using ivory knobs to convey sound directly to the ears. The diaphragm, the most used chest piece nowadays, was invented by Rober Bowles, while Sprague combined the bell with the diaphragm, in one chest piece, in 1926. Aubrey Leatham, at St. George's Hospital, in London, designed a binaural with a bell which had two components, big and small.

The 1961 Littmann could be considered a redesign of the stethoscope devised by Sprague, except that it was easier to use and much lighter; it included an "open chest-piece for the appreciation of low-pitched sounds, a closed chest-piece with

a stiff plastic diaphragm to filter out low-pitched sounds, firm tubing with a single lumen bore, the shortest practical overall length, a spring with precise tension to hold the ear tubes apart, and light and convenient to carry and use."⁷(Figure 3)

The sound heard via the stethoscope depends on three principal factors: sound (vibration) present at the chest wall, psychoacoustics (i.e. the perception of sound by the human ear) and the acoustics of the stethoscope itself. Welsby, being something of an amateur musician described the loudness of respiratory sounds at the chest wall, as either *p* (piano) or *pp* (pianissimo), equivalent to 45-60 dB.

The perception of sound is a highly complex process, but it basically consists of the triad of (a) the ability to focus on particular frequencies, (b) the presence of coexisting higher frequencies, which give the auscultated respiratory sounds their distinctive character, and finally (c) the fact that low frequency components of a sound may mask out components of a higher frequency.⁸The stethoscope acts as an acoustic filter and an impedance transformer; Abella *et al.*, found that the stethoscope bell is suited to detect sound, as the bell provides better amplification. *Au contraire*, the stethoscope diaphragm is more useful in characterizing the sound. This is because it reduces the amplification of the masking low frequency sounds more than a bell, allowing the user to hear the high frequency sounds (now unmasked) required for characterization more clearly.^{9,10}

The crucial factor in determining the usefulness of the acoustic stethoscope is its dependence on the skill and experience of the physician to detect what is normal and what is not.⁴

Electronics

Electronic stethoscopes have been available for quite some time, but these devices *per se* have generally provided only a minimum level of improvement over their mechanical predecessors. Other disadvantages include their expensive retail price, the frequent complaint of 'background noise', and that although described as 'electronic', most of the devices cannot interface with computers; but with the recent advancements in technology, these limitations are rapidly decreasing. Costs have



Figure 2: Laënnec auscultating a child's back with his stethoscope



Figure 3: An acoustic binaural stethoscope

also been falling but electronic stethoscopes are still nowadays more expensive than a good acoustic model.

The cheapest and least effective method previously used in electronic stethoscope design was the placement of a microphone in the chestpiece, which resultant in an appreciable level of interference from ambient noise. Technology currently in use includes the placement of a piezoelectric crystal at the head of a metal shaft which is in contact with a diaphragm, and the use of a diaphragm with an electrically conductive inner surface which forms a capacitative sensor. More recently, ambient noise filtering has become available in some electronic stethoscopes.^{11,12}

Woywodt *et al.*, believe that the electronic stethoscope has potential if it is exploited in the right way. They conceived the idea of using an electronic stethoscope linked to a laptop and created the necessary software to display the findings on auscultation of the precordium when a review of previous papers revealed a remarkable decline in auscultatory skills. This setup was then used in order to facilitate the teaching of cardiac auscultation.¹³

A study comparing three acoustic and three electronic stethoscopes deduced that the advantage of an acoustic stethoscope lies in its robustness and ergonomic design, but unfortunately they attenuate the transmission of sound proportional to frequency amplification. This is where the electronic stethoscope comes in. It amplifies the acoustic signal producing a more uniform frequency response. It was also pointed out that, unfortunately, electronic stethoscopes are sensitive to background noise. Overall, it was shown that acoustic stethoscopes are still preferred to electronic ones, but the conclusion was that it is possible to design a stethoscope which encompasses the advantages of both the electronic and acoustic stethoscopes.¹⁴

The Stethoscope at Ease

There appears to be a number of positions in which the stethoscope can be worn when not in use. The traditional (or T) position was the one most seen previously. This consisted of the ear pieces hanging around the neck with the stethoscope dangling down. The S position involved the stethoscope being draped over the left shoulder (if one is right handed), and is advocated by anaesthetists (such as Edward A. Petrie), who claim that it helps one maintain an erect posture and can be seen from behind as well as from the front.¹⁵ The pocket (or P) position implies letting the instrument peek coyly out of the pocket of the lab coat, something the physician J.D. Campbell ascribed to surgeons, who, recognizing the symbolism of the stethoscope early on took to carrying one, but because they lacked the understanding of its use, took to carrying it in the P position.¹⁶ The sub-axillary (SA) position, a more elegant position advocated by those doctors who still wear jackets or lab coats, is one in which the white coat is opened with a flourish, the stethoscope's ear pieces are hooked into the upper inner sleeve, and the coat is rebuttoned. However, Leak opines that this position is unlikely to attract new adherents nowadays due to it being time consuming.¹⁷

Last but certainly not least, the circumcervical or 'cool' position.¹⁸ In the last 15 years this has become the most popular position. Drs W.B. and A.J.G. Hanley associate this transition with the appearance of backward-facing baseball caps on the heads of the younger generation of doctors. They went as far as to conduct a study to determine whether the change from the traditional to the cool position would affect the efficiency and cost-effectiveness of stethoscope use. The results of the study showed that the mean time for transfer of the stethoscope from the traditional to the functional position (with the ear pieces in the examiner's external auditory canals and the head piece on the chest of the patient) was shorter than that taken to transfer the stethoscope from the cool position, the difference (mean of 1.3 seconds) being statistically significant ($p < 0.001$). Thus it can be safely concluded that the 'cool' position is inefficient. The Hanleys estimated that if the health care population of all Canada were to use the cool position as opposed to the traditional position this could amount to 71.32 hours wasted for one stethoscope placement per person per year, amounting to as much as 273, 869 hours or an annual cost of approximately \$20.5 million...¹⁹

A fascinating gadget now available online from various websites is what is known as 'The Scopeholder', which in itself is self-explanatory. Reported advantages of said gadget are that it helps improve posture by avoiding putting the stethoscope round your neck (the cool position!) and pushing the wearer into 'an unhealthy and unattractive stooped neck position'. It also allows the user to access his stethoscope more quickly, can be worn under labcoats and dress coats, and reduces the chance of misplacing your medical instrument.²⁰ Apparently there are a number of stethoscope holders on the market, from a simple clip to some more sophisticated ones. If what is claimed about them

is true, then we can only hope for a change in the placement of the stethoscope from the 'cool' position to the 'clip on' position, which would be accompanied by a decrease in the number of slouchy doctors!

Illusion of Power

The importance of the stethoscope, far from being simply an aid in diagnosing certain diseases and conditions, is, first and foremost, the symbol of a doctor's power- the doctor possessing a multicoloured mantle of a magician, along with the stethoscope of power, the healing touch, and the chronicler's pen.²¹ This has evolved from the caduceus in ancient Greece, later the physician's staff, until in the 19th century it became the white coat; which unfortunately, was usurped by the rest of the 'health care team', they being jealous of the physician's power.

Thus attention shifted to the stethoscope, which never ceased to remain distinctly representative of the physician. Campbell describes how the 'lesser orders' took to wearing the stethoscope in the hope that some of its powers would pass on to them. He continues, describing 'how some non-physician wearers of the stethoscope, not being skilled in its use, have taken to just slinging it around their necks in the cool position.' Campbell concludes that most of his younger colleagues, being unfamiliar with the use of the stethoscope and relying on the laboratory and on the diagnostic imaging department to make their diagnoses for them, have taken to wearing the stethoscope in the circumcervical position.

Back to where we started

Sir John Forbes, in the preface to the 1st edition of his translation of Dr. Laënnec's *De l'auscultation médiate*, (published in 1821), said: 'It must be confessed that there is something even ludicrous in the picture of a grave physician formally listening through a long tube applied to the patient's thorax, as if the disease within were a living being that could communicate its condition to the sense without'

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