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Historical Development, Design Features and Function of a Stethoscope

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ABSTRACT:

The medical device called stethoscope as been the medical practitioners companion and the first in the line of diagnostic actions of any patient. The medical diagnostic device (Stethoscope) was discovered by Rome Laenene at the Necker-Enfants in the year 1816. And up till date retained its early characteristics. This paper want to characterize the types of stethoscope we have today in the medical field and point out the improvement needed to be done for the new redesign of a stethoscope (Accoustics). This paper will also look into the parts of the stethoscope, their characteristics coupled with their functions and how these characteristics will be modified for a more efficient stethoscope.

Keywords: **Asculation, Historical, Characterization, Redesign, Functions**.

I. INTRODUCTION

The stethoscope is an acoustic medical device considered as the health professionals companion, hence it is symbolic of any health practitioner. Stethoscope which is viewed with other medical diagnostics devices or equivalents, has the highest positive impacts psychologically on trustworthiness of medical officer seen with it. Although many digital designs of stethoscope have been used effectively in the field, yet the Acoustic characteristics of the stethoscope still remains in every improved Redesigns of stethoscope. [1] discovered in the Electronics Stethoscope design, that the faraway of the Electret microphone used from the chest piece, the clearer the cardiac sound produced and also the more effective the reproduction of the cardiac, pulmonary or any visceral sound obtained. Hence, this paper wants to emphasize on production of stethoscope tubing with a more acoustic material so that a more audible and refined cardiac sound will be obtained; considering the African usage from local contents.

This paper characterized four different types of stethoscopes, characteristics of their parts and functions, so as to redesign a more effective stethoscope with less cost.

II. HISTORICAL REVIEW

The first reference to listening to breath sounds was in the Ebbers Papyrus in 1,500 BCE (Before the Common Era). That was almost 4,000 years ago. Some other early cases of listening to breath sounds are recorded in the Hindu Vedas from approximately 1,400 to 1,200 BCE and in the Hippocratic Writings from approximately 440 to 360 BCE [2].

The stethoscope is a standardized examination tool in healthcare and a symbol of the medical profession. Whether conducting an annual checkup or a specialized treatment, the stethoscope plays a critical role in a clinician's ability to assess, diagnose, and monitor patients. However, the tried-and-true stethoscope of the past is being upgraded with new technologies to improve provider confidence and patient outcomes.

Prior to the stethoscope's invention, doctors placed their ears against patients' chests to evaluate their health in a process called immediate auscultation. This rudimentary method proved awkward for patient-clinician relationships, and in 1816, the French physician Rene Laennec conceived that a rolled piece of paper placed between the patient's chest and his ear could amplify heart sounds without requiring physical contact. This initial development led Laennec to develop the first stethoscope device which was almost named the cylinder due to its shape. Ultimately, Laennec settled on a stethoscope because **s**tetho means chest and **scope** means viewing. The first stethoscope was a hollow wooden monaural tube with a funnel at the end. It was placed in a clinician's ear in a process called mediate auscultation, because it provided a tool intermediate between the patient and clinician.

. In the more widely spread version of the story, Dr. Lannec was consulted by an overweight young woman who was showing symptoms of heart disease. Due to her size and age, Dr. Lannec felt it was improper to put his head on her chest to listen to her heart. Despite this being common practice at the time, it was not very accurate and often led to misdiagnosis and even no diagnosis at all! To listen to the young lady's heart, he rolled up a piece of paper into a tube. He placed one end of the tube on the precordial region and in the other, he placed his ear. He discovered that the tube and its direct application to the chest made both breath sounds and heart sounds much clearer. The acoustics of the paper tube was not perfect, but they were noticeably better than the direct ear-to-chest listening that was deemed the best option at the time [3].

After discovering how effective it was, he carved a new tool with an ivory tip on both ends to conduct heat. The tool was later used to listen to the fetus inside a pregnant woman because it was found to be more accurate and powerful [4].

After Laennec's death, physicians began perfecting his design by adding earpieces so that bodily (auscultation) sounds could be heard in both ears. In 1851, Arthur Leared developed the first binaural stethoscope, and a year later in 1852, George Phillip Cammann created a flexible, rubber stethoscope for commercial use that resembles the one used today. n the 1940s, Rappaport and Sprague modified the stethoscope further to create the two-sided chestpiece. With this design, one side was used for the respiratory system and the other was for the cardiovascular system. The model was heavy and short. It was also plagued by noise artifacts created when the two tubes rubbed together. It was later abandoned.

In the 1960s, Dr. David Littmann created a lighter stethoscope with a single tube, a tunable diaphragm, and better acoustics, which created the common diagnostic tool that we know today.Along with that, special stethoscopes were designed for children that were smaller and shorter. Rubber was introduced to the general public in 1853, and the stethoscope evolved from a cone- or horn-shaped brass instrument to one with ivory earpieces, a wooden chest piece, and wooden tubing held together by rubber bands [5.6].

III. CHARACTERIZATION OF STETHOSCOPE

In 1816, Lacnnec Rene produced; rolled paper cone, later a wooden tube, it lack refined cardiac sound. In 1826, priory produced funnel shaped bell, a lightened stem, thinker earpiece for a better auscultation but still lack refined cardiac sound produced.

In 1843, Sir Williams produced the first binaural stethoscope from the horn shape device of priory, using lead pipes as the earpiece. This produce a more refined cardiac sound reproduction but lack audibility. Hence more efficient stethoscope produced.

In 1851, a scientist called Marsh produced a stethoscope with a flexible membrane chest piece, this produced a more refined cardiac sound reproductions and a more audible sounds.

In 20th century, varieties of stethoscope came out and a more design stethoscope like electronics stethoscope was designed. These developments brought about using of Bluetooth to transfer cardiac sound to the display electronic module.

In year 2022, [1] use look materials to produce a more refined cardiac sounds and a more controllable audio output, but the researcher still used the rubber tubing used previously in many stethoscope designs.

Hence, this paper want to use a material with more sound reflection as the tubing. That is using blended glass and rubber to form the tubing but care must be taken not to compromise the tubing flexibility.

STETHOSCOPE PARTS AND FUNCTIONS

Listed below are the parts of stethoscope to be considered in their paper.

- Earpiece
- Ear tube
- Tubing
- Chest piece
- Diaphragm
- Bell

- **Earpiece:** This is the part of the stethoscope that goes into the users' ear. And is for the reception of the cardiac sounds, pulmonary sounds or any other human visceral sounds. This part of stethoscope are usually made of silicome materials and are designed to produce a fitting curvature inside the ears so as to prevent unwanted sounds from interfering with the need sounds.
- **Ear Tube:** The synthetic or polyvinyl chloride tubing which connect the earpiece and the chest piece stem is called ear tubes. They are well designed to remove completely any interference from sound by any other objects in the environment of the user.
- **Tubing:** The very flexible and soft part of the stethoscope that connect our tube to the chest piece is called tubing. It is made of the same material of ear tube. That synthetic PVC. It can be single or dual lume tube dependency on the stethoscope designs. Its function is to collect cardiac sound from the chest piece bell or diaphragm and maintain continuous transfer of this sound to the ear tube and finally to the ear piece. Hence the audibility of cardiac sound produced at the ear piece will depend on the integrity of the tubing.

- **Chest piece:** This is combination of diaphragm and or bell. This serves as the sensor of the cardiac sound while the tubing serves as the signal transmitter. It picks the sound and amplified it to some extend due to the materials it is been made of. Chest piece can pick a sound when applied to the patients skin, while some more stronger chest piece can pick a sound even when applied against patients skin cloth on the chest.
- **Diaphragm:** The more larger and more circular and of the chest piece is called diaphragm. It is used by the physician to pick up a more higher frequency cardiac sounds and could be applied to a wider area when compared to the bell side of the chest piece.
- **Bell:** This is a more narrower side of chest piece that is been used to pick up a low frequency sounds, which can be also be detected by the diaphragm side of the stethoscope. It can be provided with more design variations to increase patients comfortabilities.

IV. STETHOSCOPE WORKING PRINCIPLE

Cardiac, pulmonary or other human visceral sound produced in the human body can be pack up by the stethoscope Diaphragm or Bell end, when the chest piece N pressed against the patient chest region, abdominal region and so on. The cardiac sound will be amplified a little bit by the Bell or diaphragm based on the audio properties of the materials used to produce the chest piece.

The amplified sound will now be channel through the stethoscope tubing with more amplification in the tube. This amplification will be based on ʌ = $\frac{V}{f}$

Where Fo = $\frac{V}{ʌ}$ ---------- i

Where Fo = frequency of the cardiac sound which can be low (less audible) or high (more audible). Note that the velocity of the sound can be made constant, so the tubing will solely depend on the wavelength (ʌ). Since the air pressure inside the tubing of the stethoscope is higher than the air pressure outside the tubing. When the sound wave come in contact with any open end, this change in pressure will make the wave to be reflected down the tube, but the stethoscope open end is the our price which opens directly into the users ear, hence the down reflection of the sound will make the previous sound and the new sound to link together and thus continues production of the audible cardiac sounds.

In an air tight stethoscope, the standing wave behaves like that of a closed pipe (one end closed). In which a node is forced at the closed end, that is no air molecules is allowed to vibrate up and down which allows the continuous upward movements of the cardiac sound produced. That is an autinode occurs at the open end of the stethoscope (i.e air piece). From equation1 above.

Fo = $\frac{nv}{4L}$ ---------------ii where n = odd number if we make n and v to be constant than equation (ii) will becomes Fo = $\frac{1}{4L}$ -------------- (iii)

Which implies that the frequency of the sound produced in a stethoscope is inversely proportional to the length of the tube, the lower the frequency produced.

Also if we make length of the tubing to be constant, then the equation (iii) will become;

Fo = nv ------------ (iv)

Remember that the velocity of sound in the tubing will be constant.

Hence equation ---(4) will becomes Fo = n

Where n is nodes, which the integrity will depend on the reflection of the inner linings off the tube.

V. MATERIAL AND EQUIPMENT USED.

- Previous stethoscope tubing
- Glass/optical fibre
- Chest piece
- Constructed earpiece

VII. CONSTRUCTION METHOD

The optical fibre in form of liquid is forced to flow through the tubing of uniform diameter(predefined diameter) at a constant speed so that there will be uniformity of coating. After coating the chest piece is installed tightly on the tubing. It must be air tight so as to make the tube behave like closed tube resonance device.

The air piece was constructed to be the nose so that the earpiece can potion of the user.

VII. TESTING AND TROUBLE SHOOTINGS

After the full construction and assembly of the stethoscope, the testing was done on ten (10) patients and the results are given in the table below.

SAMPLE (PATIENT)	SYSTOLIC SOUND	DIASTOLIC
A	100 mm Hg	80 mm Hg
B	110 mm Hg	90 mm Hg
C	100 mm Hg	80 mm Hg
D	100 mm Hg	70 mm Hg
E	100 mm Hg	80 mm Hg
F	110 mm Hg	90 mm Hg
G	120 mm Hg	70 mm Hg
H	110 mm Hg	80 mm Hg
I	100 mm Hg	70 mm Hg
J	120 mm Hg	80 mm Hg

The constructed stethoscope was used with syphigmomanometer to get the readings in the table 1 above.

The constructed tubing was removed and another tubing without optic fibre line was installed and tested on the same patients. It was discovered that the same result were obtained but the audibility is lower when compared with the tubing with optical fibre lining and shorter tube length.

VIII. CONCLUSION

Based on the results analyzed above from the two types of stethoscope tubing, It can be concluded thus that the shorter the length of the stethoscope tubing the higher the frequency of the cardiac sound produced and that the tubing increase reflection speed of the sound. Also the more curved forward of the earpiece, the more airtight to the audiotary canal of the users.

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