A New Stereophonic Stethoscope

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SUMMARY

A new stereophonic stethoscope is presented. It is characterized by a single chest piece construction housing paired open-bell type sound accumulating chambers and paired diaphragm type sound accumulating chambers. A pair of separate ear tubes connected to each of the paired sound chambers establish two cross talk-free channels for collecting and delivering auscultatory sounds. Selective use of the open-bell and diaphragm sound chambers is assured with this new stethoscope. Advantages of stereophonic auscultation are discussed.

Additional Indexing Words:

Auscultation

WITH the commonly available stethoscopes of today we can hear only monaural sounds; i.e., all the sounds originating in the chest are heard centered midway between our ears, and we cannot perceive directionality and spatiality of sounds. This is because the present-day stethoscopes are single-channel stethoscopes; their binaural tubings are connected to one sound accumulating chamber in the chest piece.

It has been the author's belief that if we had a two-channel stethoscope, we ought to be able to hear stereophonic sounds. This is because time differences and phase shifts of sounds, which are two essential components that enable stereophonic perception of sounds in our auditory system, can be perceived only when each of our ears has a separate sound channel of its own. Then we should be able to differentiate sounds which spread widely from sounds which center at a point. For instance, cardiac murmurs are produced by turbulence of the blood flow, hence origins of cardiac murmurs are distributed widely. This kind of sound ought to be heard spread widely, just like the applause of a large audience in a concert hall. On the other hand sounds such as heart sounds and closing and opening clicks of mechanical valve prostheses originate at a particular point in the chest. These kinds of sounds ought to be heard centered at a point, just like one person's hand-clap in a concert hall. Thus stereophonic auscultation ought to be able to

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Fig. 1. Newly conceived stereophonic stethoscope. A pair of semicircular diaphragm sound chambers are separately connected to one and the other of the paired ear tubes housed in the single tubing, thus a complete double channeling is established. Inset, the paired semicircular open-bell sound chambers positioned opposite to the diaphragm sound chambers.

augment the diagnostic acumen of auscultation by differentiating sounds of different nature.

New Stereophonic Stethoscope:

With this concept in mind the idea of a new stereophonic stethoscope was conceived by the author¹⁾ and a prototype was fabricated (by Yamasu, Inc., Saitama, Japan). Essentially, this new stereophonic stethoscope houses a chest piece in which an open-bell sound accumulating chamber and a diaphragm type sound accumulating chamber are positioned opposite each other (just as in the present-day stethoscope), and both the open-bell and diaphragm sound chambers are divided into right and left semicircular sound chambers by a central partition. A pair of ear tubes are connected separately to the right and left semicircular sound chambers (Figs. 1 and 2). Thus in this new stethoscope a thorough duality of sound channels is established from the point of sound accumulation up to the point of sound delivery for both the open-bell and diaphragm sound chambers. Therefore, this stethoscope

Fig. 2. Cross section of the chest piece of this stethoscope. Note that both the open-bell sound chamber and the diaphragm sound chamber are divided into right and left semicircular sound chambers by central partitions.

ought to be able to transmit stereophonic sounds to the examiner. And it is to be noted that its general size and configuration are comparable to those of present-day stethoscopes, and the convenience of the selective use of the open-bell sound chamber and the diaphragm sound chamber is retained with it.

Measurement of Cross Talk:

It is essential that the two channels of this new stethoscope are well insulated from each other in terms of sound collection and delivery to achieve good stereophonic effects. Figure 3 illustrates the method of cross talk measurements employed in this report. Sound vibrations of various frequencies were generated in the diaphragm (D) at the top of the speaker box (SPB) by activating the speaker (SP). The vibrations thus generated in the diaphragm (D) were delivered to one of the semicircular diaphragms of the chest piece (CP) of the tested stethoscope, which was mounted above the diaphragm of the speaker box by a coupler (CR) inserted between the two diaphragms. The intensity of the sound generated in the speaker box was maintained at a constant level while audio frequencies were changed. Audio outputs were recorded in the ear tube connected to the activated semicircular diaphragm (signal output) and in the ear tube of the other side (cross talk output). As shown in Fig. 4, there were only small cross talk outputs, which validates the effectiveness of double channeling in this stethoscope.

Fig. 3. Diagram illustrating the method of cross talk measurement. SPB=speaker box; SP=speaker; D=diaphragm; CP=chest piece of the stethoscope; CR=coupler; MIC=microphone; S=stethoscope; EP=ear piece; MIC CR=microphone coupler; MA=microphone amplifier; CA=compressor amplifier; PA=power amplifier; PDM=paper drive motor; OSC=oscillator; PF=paper feeder.

Fig. 4. Signal output (S) and cross talk output (C). Note that there are only minimal cross talk outputs.

User Trials:

It is extremely difficult to provide proof of the stereophonic effects by means of audio recordings or any other concrete data. Indeed, stereophonic effects can only be proved by one's perception. Therefore, results of the evaluation of this new stereophonic stethoscope can be presented only by impressions dictated by the examiners. Nearly every one of the early examiners (physicians and nurses) who did clinical auscultation with this new stethoscope commented that he/she heard the kind of sounds that he/she had never heard with currently used stethoscopes. Some expressed them as indeed stereophonic sounds, and others expressed them as "dynamic, moving sounds". The author's own critical evaluation of the results of

Fig. 5. Hitherto conceived two-channel stethoscopes. a, Alison and other investigators,²⁾⁻⁸⁾ b, Boston,⁹⁾ Fröschels,¹⁰⁾ c, Kerr,¹¹⁾ d, Kerr,¹¹⁾ Yamamoto,¹³⁾

auscultation done with this new stereophonic stethoscope has been strongly positive. Cardiac murmurs were heard spread widely just as anticipated. Respiratory sounds were heard spread widely as well, but this is quite understandable if one remembers that their origins are widely distributed. Heart sounds and sounds of mechanical valve prostheses were definitely heard as sounds centered at a point, and it was noteworthy to be able to hear some distinct resonating sounds accompanying the latter sounds. Points of maximal intensity of cardiac murmurs were always easier to determine with this stereophonic stethoscope, for the relative difference of intensities of murmurs heard by the right and left ears indicate from which direction the murmurs are coming.

DISCUSSION

The first two-channel stethoscope was introduced by Alison in 1858.¹⁾ It consisted of two complete stethoscopes, each with its chest piece and ear tube, the two being mechanically connected (Fig. 5a). It was called the double or differential stethoscope, and was employed for comparing sounds which take origin from two different points. Two-channel stethoscopes of this type were repeatedly introduced in later years (Fig. 5a, b),³⁾⁻¹⁰⁾ but none of them found to be clinically useful in the medical profession. Kerr introduced in 1936 "the symballophone",¹¹⁾ which is essentially an Alison stethoscope with one or two shunt tubes connecting the two stethoscopes (Fig. 5c, d). Kerr made a strong case for the symballophone,¹²⁾ but it has

been totally forgotten to date. Yamamoto and Arakawa reported a modification of the Kerr stethoscope in 1970.¹³⁾ Hartert introduced one other modification of the Alison stethoscope in which the two chest pieces were fixed side by side to form a rectangular, single chest piece.¹⁴⁾ It was meant to be a special stethoscope for auscultation in the intercostal space. However, this stethoscope did not find much use among clinicians.

It is not difficult to understand why these two-channel stethoscopes went into oblivion. First, they are cumbersome to handle, since one has to employ both hands to manipulate them. The Hartert stethoscope is a single-chest piece stethoscope, but it still has a large, rectangular chest piece. Second, one gains no particular advantages in auscultation by using them. Only unnatural or even annoying sounds are heard, and practically no stereophonic sounds are perceived. One must remember that sounds originating in the chest are so low in intensity that they are radiated to only a small area of the chest wall. The two chest pieces of the Alison stethoscope (and its modifications including the Hartert stethoscope) override the small area where a faint sound is radiated from within the chest. Therefore, sounds from different origins are conveyed to one's right and left ears, which in almost all cases are perceived as unnatural sounds. On the other hand, the two semicircular sound accumulating chambers of the stereophonic stethoscope presented here are positioned at the closest proximity to each other so that they do not override the small area where a faint sound is radiated. Therefore, sounds from the same origin are conveyed to both of the examiner's ears; but, there are time and phase differences between the sounds reaching the right ear and the sounds reaching the left ear. These time and phase differences of sounds give rise to a stereophonic perception of sounds.

One may wonder about the advantages of stereophonic auscultation. The author feels that stereophonic auscultation is just more natural than monaural auscultation in the first place, since in stereophonic auscultation sounds are probably heard just the way they are occurring. Secondly, he feels it is easier to hear faint but important sounds such as murmurs of early-stage aortic insufficiency and opening clicks of mechanical valve prostheses. This is probably because respiratory sounds, which mask faint cardiac sounds when conventional stethoscopes are used, do not mask these faint sounds, since the former sounds are heard spread out.

It is possible that this new stereophonic stethoscope may contribute to the art of auscultation.

ADDENDUM

A U.S. patent was granted for the stethoscope presented herein in October, 1988.¹⁵⁾

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