

Diagnostic Visual Information of Heart Sounds

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Opinion

In addition to speech, which is the most important carrier of information for understanding and communication, our body also generates the sounds of breathing, snoring, cracking joints and, of course, the sounds of the heart. These sounds also contain certain information about our health, we just need to know how to interpret them. For the interpretation of some sounds, especially when it comes to the sounds of the heart, our hearing is limited and in many cases the interpretation of these sounds is difficult.

When we visualize sound, i.e. graphically, we can visually interpret sound information. In this way, we have increased the possibilities of interpreting diagnostic sound information. Also, the ability to simultaneously listen to and see the sound of the heart helps doctors to better recognize and evaluate the events of the heart cycle and thus more reliably determine the cardiology diagnosis of patients.

However, when interpreting visual representations of heart sounds, we have the same problem as with auscultation. As with the interpretation of the sound of the heart by auscultation, so with the interpretation of their sound images, it is first necessary to visually map the events of the sound cycle of the heart: first and second heart sound S1 and S2; systole and diastole. After that, the basic classification of image representations of heart sounds is made into sound images of normal healthy heartbeats without noise and those with some noise. Another diagnostic classification is the classification of sound images with innocent and pathological noise. The third classification is specific, i.e. reliable diagnosis of pathological murmurs. Certain deformations (diseases) of the heart affect the resonant structures of the heart, which is reflected in the sound of the heart that the doctor listens to and interprets. Of course, when we present the sound of the heart with a pictorial record, it is reflected in that record as well. Therefore, based on the audio interpretation of the sound and/or the visual interpretation of the image of the heart sound, the correct diagnosis of the patient should be determined.

Diagnostic procedure:

Audio cycle event mapping.

The patient is healthy without noise or has some noise.

Noise benign or pathological.

Accurate diagnosis of pathological noise.

The events of the cardiac cycle are periodically repeated over time. In visual representations of heart sounds, the horizontal axis regularly represents time. At each moment in time, cardiac

cycle events have amplitude characteristics that we read on the vertical axis of the signal display. With the heart sound spectrogram, we read the distribution of the spectral energy of the heart sound over time on the vertical axis, and with the PCG phonocardiogram, the time display of heart sound amplitudes. Murmurs of different causes (e.g. VSD, ASD, Stenosis, etc.) appear during systole or during diastole. If they appear in systole, they can be heard during systole and seen in systole on visual displays. Diastolic murmurs are heard during diastole and are reflected on the visual representations in diastole. With spectrogram representations of heart sounds, the mapping of sound cycle events as well as the classification of murmurs (if present) is determined on the basis of time-frequency representations.

By comparing the distribution of spectral contents in time intervals, the events of the cardiac cycle are mapped (located) and, if present, noise is located and evaluated. With the sounds of a normal heartbeat (without noise), the sound of the first and second tones S1 and S2 is heard, and between them, i.e. during the duration of systole and diastole, we do not hear sounds of significant intensity. The sound of ambient noise and artifacts can be heard if they occur. On the spectrogram representation of that sound, you will see the reflection of the sound energy in the time intervals of the appearance of S1 and S2, and in the time intervals between them there will be no dimming, which represents the intensity of the spectral energy in those time intervals. Thus, we will have "clean" systole and diastole on spectrogram representations of the sound of a normal heartbeat. The same conclusion applies to the graphic representation of heart sound over time - PCG. During the time intervals of occurrence of S1 and S2, the PCG curve will have pronounced amplitudes, and during the time intervals between them, the amplitudes will be negligible. If during systole or diastole a noise appears that can be heard with a stethoscope, it is clear that the reflection of its energy will be seen on the spectrogram as well as on the temporal PCG representation of the heart sound. Murmurs of different origin, i.e. the cause of their occurrence, change the acoustic characteristics of the heart.

Therefore, the sounds of heart murmurs are caused by different heart deformations with different acoustic characteristics, i.e. their sound is different, but our hearing is mostly not capable of determining these differences and determining a reliable diagnosis of the murmur, i.e. the patient's illness. However, we can see the difference in the acoustic characteristics of murmurs on graphic and pictorial representations of heart sounds. Every acoustic change in the sound has its own reflection on the time and frequency characteristics when we visualize that sound, so auscultatory diagnostics can be helped in this way. It means that features of sound that we cannot interpret by hearing may be able to be interpreted on visual representations of that sound. Of course, just as with sound, depending on the quality of the stethoscope, we have

a clear or unclear sound, and with sound images, the same problem remains - the quality of the display of sound images. It should be noted that the basic requirement for obtaining high-quality representations of sound images of heart signals is a satisfactory quality of the heart sound recording. So, the first thing to take care of is choosing a stethoscope. If we assume that we have a sound of satisfactory quality, it is necessary to have a software package that processes the sound of the heart well and displays images of the processed sound well (PCG, Spectrogram; and many other solutions for displaying these sounds). Here, the time-spectral resolution in signal processing and determination of links remains a problem: pathology - time-spectral characteristics of the signal.

With the graphic presentation of the heart sound (e.g. PCG), we monitor the signal amplitudes over time. In the time intervals of occurrence of S1 and S2 (last approx. 50ms), signal amplitudes are expressed, while during systole and diastole, if there is no heart murmur, there are no expressed signal amplitude values. If the display of the patient's heart sound is observed with some noise on the heart, then the sound of the noise will be reflected in the amplitude values of the signal during systole or diastole. If the noise is systolic, we will have the appearance of signal amplitude values during systole, and if it is diastolic, during diastole. Of course, as we have already mentioned, the same applies to the spectrogram, only then we look and compare the distribution of spectral energies over time. In the time intervals when the heart sounds appear, the frequency components are expressed at lower frequencies, so the heart sounds can be clearly seen on the spectrogram. In some cases, heart sounds are more clearly seen on PCG. Also, sometimes it is easier to recognize S1 and S2 on PCG and thus determine systole and diastole, i.e. classify systolic and diastolic murmurs. However, noise assessment, i.e. classification into pathological and innocent, as well as a concrete diagnosis of pathological noises, is possible through the interpretation of spectrograms. On PCG we can see the appearance of murmurs and determine whether the murmur is systolic or diastolic.

Each heart murmur generates its own characteristic sound, so the spectrograms and PCG records of these sounds will have their own characteristics. In the case of spectrograms, these are the frequency contents over time, and in the case of PCG, the morphological forms of the amplitude values of the PCG curves over time. However, with PCG, the links (correlations) of graphic morphologies and diagnosis of murmurs are mostly not determined, while with spectrograms, some links between the frequency spectrum of murmurs and cardiac diagnosis are determined. It should be noted that these links are insufficiently researched and defined and are still insufficiently reliable tools for reliable cardiac diagnosis. Thus, there is a significant unexplored area for the audio-visual classification of heart murmurs, which represents a great challenge and potential for some new research.