Phonocardiography in an Echocardiography room

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Abstract. In Mexico City at Universidad Autónoma Metropolitana Azcapotzalco (UAMA), with the aim to build a Computerized Diagnostics System of Cardiac Diseases based on the sound emitted by the heart, a research project is conducting. Cardiac sound is captured in a computer through a data acquisition system which it transforms in an image that will be analyzed later. Along years, several methods had been developed in different institutions of various countries looking for identify in phonocardiograms cardiac pathologies, some of them using complex mathematical algorithms for medical sector, which make difficult to understand and apply. At UAMA we can recognize image alterations of acoustic wave by means of a visual and computerized method in which its possible identify possible damages in the different heart’s components. To get a set of images of phonocardiograms of people with different heart disease, diagnosed and being treated, phonocardiograms were taken to ambulatory patients seen in the Echocardiography office at a High Specialty Hospital. We show the obtained images and his correlation with the diagnosed cardiac diseases.

1. Introduction

Diseases that occur in the heart, by their origin, can be classified as: from the myocardium, the valves, the electric conduction, the Pericardium, the Coronaries, the arteries, the veins. A single type can occur, although most of the time they occur mixed.

In its operation, the heart emits a series of sounds caused by the movement and closing of its four valves, the movement of the blood fluid or the friction with the pericardium. Sounds can be heard in the Doctor's office, with the stethoscope. There is a pattern of sounds emitted by a healthy heart. Alterations in this pattern allow to identify the different cases of heart disease. This type of diagnosis requires a stethoscope in good condition and a doctor perfectly trained to recognize each of the normal sounds and their alterations in intensity and duration. [1], [2], [3].

Due to the great advances in technology of Electronic Instrumentation, sophisticated instruments have been created that allow the heart to be visualized in its internal structure and dynamic operation. These are the Magnetic Resonance System, the Computerized Tomography and the Echocardiograph.

These wonderful instruments provide more information than the stethoscope, so Doctors prefer to send patients for one or more high-tech studies, but such equipment is only available in large cities and the cost of studies is very expensive. This alternative has also created a problem in the professional training of Physicians since in their specialty studies they now spend less time training to identify the sounds they hear with the stethoscope [4], [5].

2. Phonocardiograms

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To be able to interpret easily and in an economical way, the sounds emitted by the heart and perform a
diagnosis, the sounds are captured on a computer and an image of them is made.
That image is called a Phonocardiogram. Although Phonocardiography was born a few years ago [10],
the problem now is training medical staff in visual recognition of alterations in images of sounds from sick
hearts. To achieve this, it is necessary to have at hand a set of images associated with different diseases.

3. Methodology
In order to verify that the information obtained through phonocardiograms, PCG, contains all the elements
necessary to diagnose a heart condition, a correlation was made of a phonocardiogram taken on a patient
with a heart disease with information obtained through an echocardiogram performed at a high-speciality
medical center in the cardiology section.
A 60-second phonocardiogram was obtained using an electronic stethoscope and a computerized data
acquisition system with a sampling of 4000 data per second. With LabView software, sounds were
processed to display it as an image, which can be showed at different time intervals.

4. Results
Phonocardiograms were obtained, from sounds heard at four different sites of the chest of patients diagnosed
with the cardiac pathologies: Ischemia, Heart Growth, Left Ventricular Diastolic Dysfunction, Infarction,
inflammation of the Pericardium, Calcified Valve, Arrhythmia. Because the available space here is short,
we only show in the next figures some of the Phonocardiograms obtained.

4.1. Normal Case

Figure 1. IHM2 210219. PCG taken at sitting position in Pulmonal site. Display of 5 seconds. Pairs S1 and
S2 are well defined. There aren’t intermediate sounds in systole and diastole.

4.2. Ischemia
Ischemia is the term used to indicate that there is a lack of blood supply to the heart. This can cause the
heart muscle not have enough energy to propel blood to the circulatory system. There will be faint heartbeats
and faint sounds. Bradycardia is likely to occur as well. If the amount of blood flowing to the heart is
enough, the tissues will be irrigated and there will be no damage. If blood flow is low, parts of the tissue
may die. Severe pain and other symptoms will occur.

Figure 2. RAR4 210219. Taken at supine in Mitral site. 5 second sample displayed. There’s Split on S1.
There is an early murmur in the systole. There is also an early murmur in the diastole. There are Pulmonary
valve stenosis with regurgitation in the mitral, aortic, and pulmonary valves.
Figure 3. NRR22 210219. PCG taken sitting at pulmonal site. 5 second sample displayed. There is a continuous murmur in the diastole. There are 2 important noises inside the systole indicating stenosis in aortic and pulmonary valves, and mitral valve prolapse. There are Aortic and Mitral Regurgitation.

4.3. Heart Growth
The heart grows because the patient has had long suffered high blood pressure. The heart muscle must exert more force to send the blood causing its growth. It may be that only the ventricles have increased in size, as well as the outer tissue that surrounds them.

Figure 4. LMD4 190219. PCG taken at Decubitus in Mitral site. 5 second sample displayed. There is Split on S1 and S2. There's a rising murmur in the systole. There are Pulmonary valve stenosis and regurgitation in mitral and tricuspid valves. There's regurgitation in the aortic and pulmonary valves.

4.4. Left Ventricular Diastolic Dysfunction
In this case it is the left ventricle, which is grown, presenting an incorrect closure in the aortic valve and regurgitation. There is also a diastolic murmur and Split in S2.

Figure 5. MMF4 140219. PCG taken at decubitus in Mitral site. 5 second sample displayed. There's evidence of arrhythmia. The S1, S2 pairs are not defined. There is an early systolic murmur. There is pulmonary stenosis with mitral regurgitation. There are Aortic stenosis and Mitral valve prolapse.
4.5. Previous infarction
In this case, because there has been a lack of blood supply to the heart, some of the heart tissue died. But the side effects to this depend on which tissues were specifically damaged. In the case of the patient being studied, the damage was on the intraventricular wall. So, filling and pumping the ventricles was not adequate.

Figure 6. HMS2 140219. PCG taken at decubitus in Pulmonary site. 5 second sample displayed. There's murmurs in systole and diastole. There's Split on S1. There are Pulmonary stenosis and Regurgitation in mitral, tricuspid, and aortic valve.

Figure 7. HMS4 140219. PCG taken at decubitus in Mitral site. 5 second sample displayed. There is noise before S1, could be Split on S1. There is a Murmur that erases S2 in the space of the systole and diastole. There are Aortic and pulmonary stenosis. Also, Mitral, tricuspid, and Aortic regurgitation.

4.6. Inflamed Pericardium

Figure 8. GOH3 250419. PCG taken at lateral decubitus in Tricuspid site. 5 second sample displayed. Split on S1. Split on S2. There is Murmur in diastole and systole. There are Mitral and tricuspid stenosis and aortic regurgitation.
Figure 9. GOH4 250419. PCG taken at lateral decubitus in Mitral site. 5 second sample displayed. There is split on S1. Mitral and tricuspid valves do not close simultaneously. There is a 4th sound before S1. There is a 3rd sound on diastole. There are Aortic and Mitral stenosis.

4.7. Calcified Valve
The edges of the valve holes and mitral and tricuspid valves have calcium deposits and are hardened. It is not possible for the valves to close properly, with regurgitation and blowing in systole, in addition to Split in S1. Could it also be the case in the aortic and pulmonal valves.

Figure 10. MHD4 280219. Taken at Decubitus in Mitral site. 5 second sample. There is a continuous murmur in the diastole that hides S2. Aortic and Mitral regurgitation.

4.8. Arrhythmia.
This is a problem caused by a defect in the electrical conduction of the heart or a consequence of Hypothyroidism. The electrical signal inside the heart to contract and expand is not uniform, causing different time intervals in the systolic and diastolic cycles. Succession of S1, S2 pairs is not uniform.

Figure 11. EFG4 140219. PCG taken at lateral decubitus in Mitral site. 5 second sample displayed. There is no uniformity in the separation between the main peaks. There is also aortic stenosis.

5. Discussion
In the Phonocardiograms showed in figures 2 to 11 can be seen the alterations in the wave form respect to sounds emitted by a healthy hearth, figure 1.

Results described contains information from Phonocardiograms and Echocardiograms, taken to the same person previously diagnosed with heart disease, in each different case. By comparing the results of both methods allowed us to get an accurate diagnosis of the disease. This gives certainty to the previously discussed phonocardiogram analysis methodology [9], [10], [12].

6. Conclusions
In order to set up a set of images of phonocardiograms of people with different heart disease, diagnosed and being treated, phonocardiograms were taken to outpatients seen in the Echocardiography office at a High Specialty Hospital. Information obtained from PCG was completed with that obtained from echocardiography.

The use of Phonocardiograms is a feasible and economical method for diagnosing heart disease, but a special training program is required for future physicians.

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