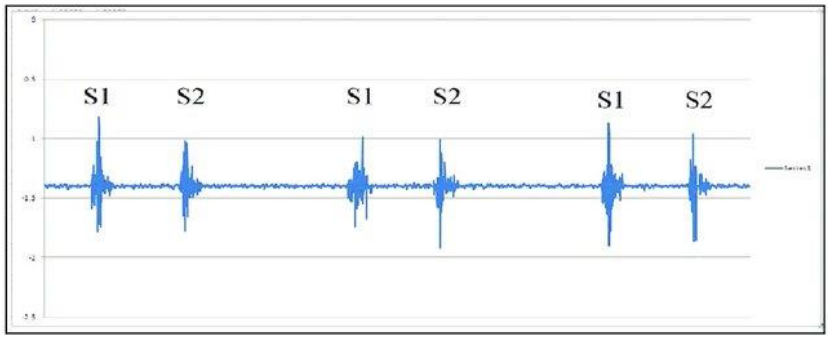
Heart Sound Signal Classification

A **normal heartbeat** has two sounds, a lub (sometimes called S1) and a dub (S2). These sounds are caused by the closing of valves inside your heart.

If there are problems in your heart, there may be additional or abnormal sounds.



1. Abnormal heart sounds
   a. S_1 (e.g., mitral stenosis, atrial fibrillation)
   b. S_2 (e.g., hypertension, aortic stenosis)
   c. S_3 (e.g., heart failure)
   d. S_4 (e.g., hypertension)
   e. Abnormal splitting (e.g., atrial septal defect)

2. Systolic murmurs
   a. Ejection murmurs (e.g., physiologic, aortic stenosis)
   b. Pansystolic murmurs (e.g., mitral regurgitation)

3. Diastolic murmurs
   a. Early (e.g., aortic regurgitation)
   b. Mid-diastolic (e.g., mitral stenosis)

4. Pericardial friction rubs

The most common abnormal heart sound is a heart murmur. A murmur is a blowing, whooshing, or rasping sound that occurs during your heartbeat.

There are two kinds of heart murmurs:

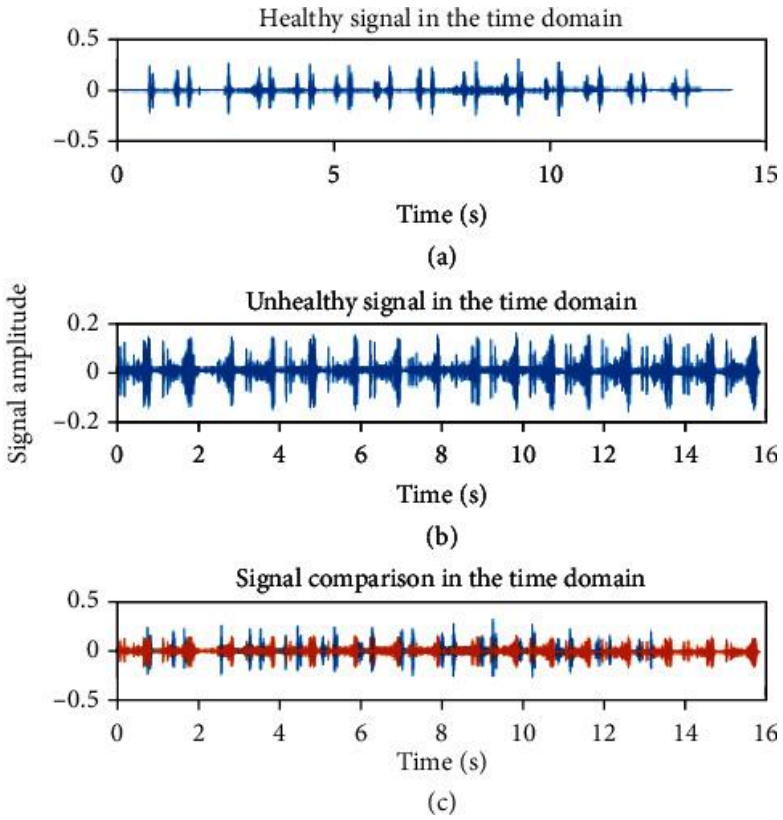
- innocent (also called physiological)

  It's caused by the sound of blood moving normally through the heart.

- Abnormal

  An abnormal murmur in a child is due to congenital heart malformations, which means they're present at birth. It may need to be corrected with surgery.

  An abnormal murmur in adults is usually caused by problems with the valves that separate the chambers of your heart.



Normal Category

In the Normal category there are normal, healthy heart sounds. These may contain noise in the final second of the recording as the device is removed from the body. They may contain a variety of background noises (from traffic to radios). They may also contain occasional random noise corresponding to breathing, or brushing the microphone against clothing or skin. A normal heart sound has a clear “lub dub, lub dub” pattern, with the time from “lub” to “dub” shorter than the time from “dub” to the next “lub” (when the heart rate is less than 140 beats per minute). Note the temporal description of “lub” and “dub” locations over time in the following illustration:

…lub…….dub……. lub…….dub……. lub…….dub……. lub…….dub…

In medicine we call the lub sound "S1" and the dub sound "S2". Most normal heart rates at rest will be between about 60 and 100 beats (‘lub dub’s) per minute. However, note that since the data may have been collected from children or adults in calm or excited states, the heart rates in the data may vary from 40 to 140 beats or higher per minute. Dataset B also contains noisy_normal data - normal data which includes a substantial amount of background noise or distortion. You may choose to use this or ignore it, however the test set will include some equally noisy examples.

Murmur Category

Heart murmurs sound as though there is a “whooshing, roaring, rumbling, or turbulent fluid” noise in one of two temporal locations: (1) between “lub” and “dub”, or (2) between “dub” and “lub”. They can be a symptom of many heart disorders, some serious. There will still be a “lub” and a “dub”. One of the things that confuses non-medically trained people is that murmurs happen *between* lub and dub or *between* dub and lub; not *on* lub and not *on* dub. Below, you can find an asterisk* at the locations a murmur may be.

…lub..****...dub……. lub..****..dub ……. lub..****..dub …….…. lub..****..dub …

or

..lub…….dub…******….lub……. dub…******….lub ……. dub…******….lub …….dub…

Dataset B also contains noisy_murmur data - murmur data which includes a substantial amount of background noise or distortion. You may choose to use this or ignore it, however the test set will include some equally noisy examples

Extra Heart Sound Category (Dataset A)

Extra heart sounds can be identified because there is an additional sound, e.g. a “lub-lub dub” or a “lub dub-dub”. An extra heart sound may not be a sign of disease. However, in some situations it is an important sign of disease, which if detected early could help a person. The extra heart sound is important to be able to detect as it cannot be detected by ultrasound very well. Below, note the temporal description of the extra heart sounds:

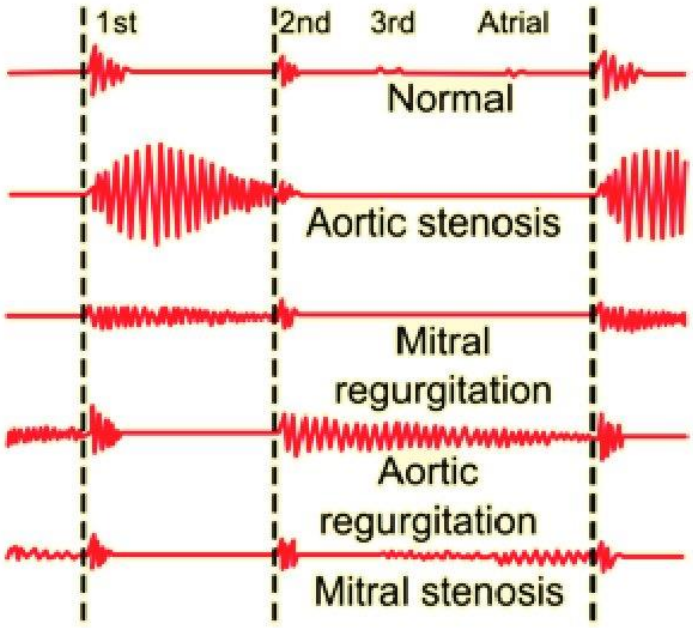
…lub.lub…….dub…..……. lub. lub…….dub…….lub.lub……..…….dub…….

or

…lub……dub.dub…….lub.…….dub.dub…….lub……..…….dub. dub……

There are some samples of audio heart sound signals in the following link:

https://www.kaggle.com/code/mychen76/heart-sounds-analysis-and-classification-with-lstm



The types of heart murmurs and other abnormal sounds:

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If there are problems in your heart, there may be additional or abnormal sounds.

Heart murmurs

The most common abnormal heart sound is a heart murmur. A murmur is a blowing, whooshing, or rasping sound that occurs during your heartbeat.

There are two kinds of heart murmurs:

- innocent (also called physiological)

  It's caused by the sound of blood moving normally through the heart.

- Abnormal

  An abnormal murmur in a child is due to congenital heart malformations, which means they're present at birth. It may need to be corrected with surgery.

  An abnormal murmur in adults is usually caused by problems with the valves that separate the chambers of your heart.

Galloping rhythms

Other heart sounds include a "galloping" rhythm, which involves additional heart sounds, S3 and S4:

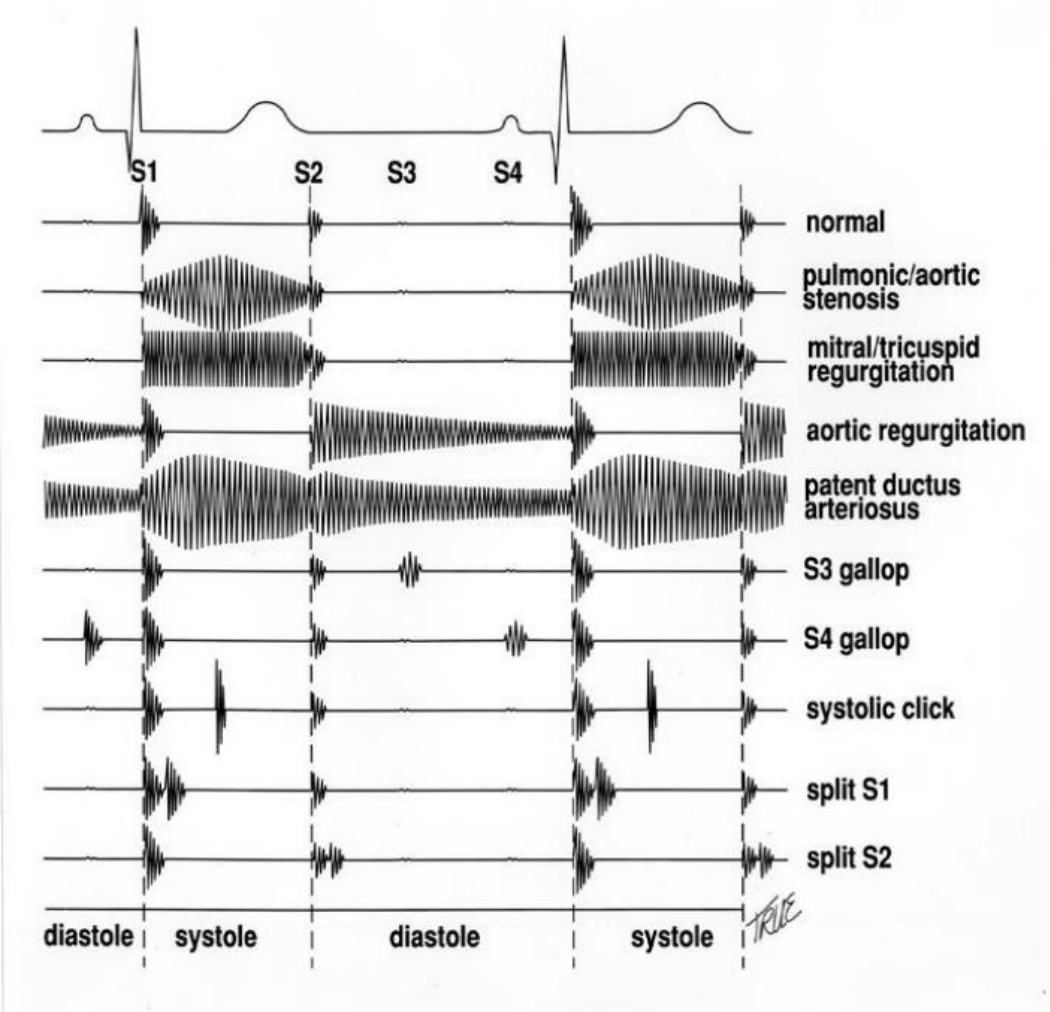
- **An S3 gallop** or "third heart sound" is a sound that occurs after the diastole S2 "dub" sound.
- **An S4 gallop** is an extra sound before the S1 systole "lub" sound. It's always a sign of disease, likely the failure of the left ventricle of your heart.

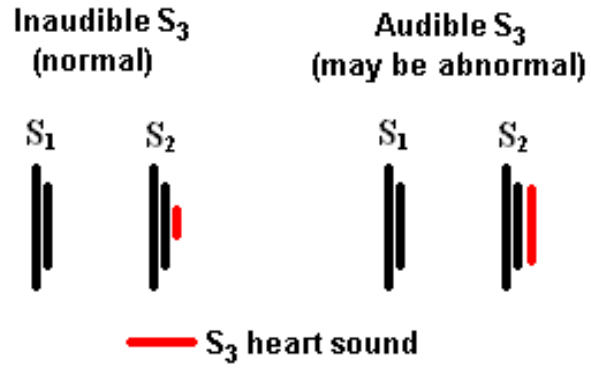
You can also have both an S3 and an S4 sound. This is called a "summation gallop," which can occur when your heart is beating very fast. A summation gallop is very rare.

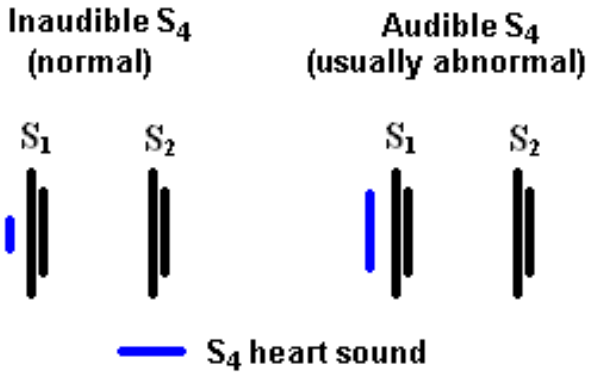
Abnormal heart sounds are called heart murmurs. A heart murmur may occur in between regular heartbeats and sound like one of the following:

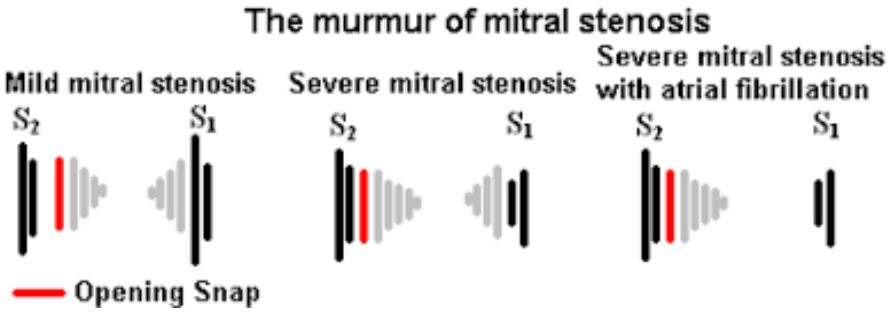
- a rasping
- a whooshing
- a blowing

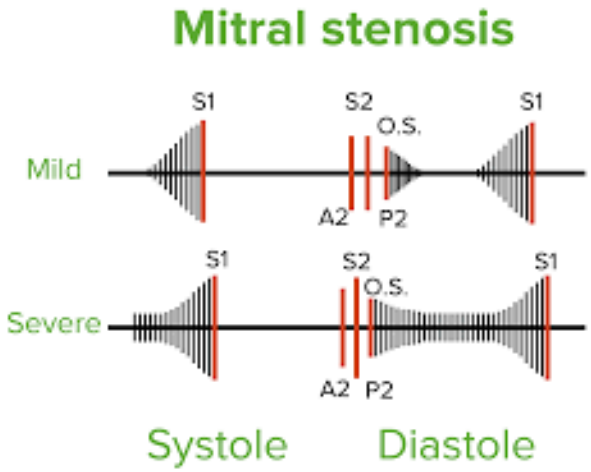
Another classification with more detailed features is shown in the following figure:

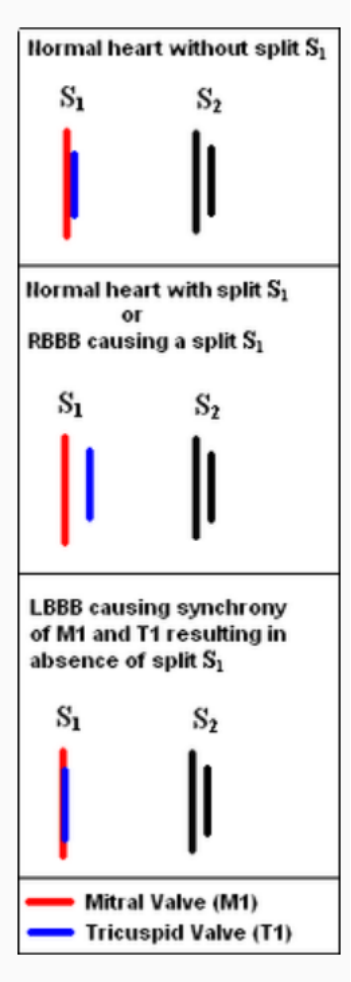



Inaudible S_3
(normal)
Audible S_3
(may be abnormal)
S_1
S_2
S_1
S_2
S_3 heart sound


Inaudible S_4
(normal)
Audible S_4
(usually abnormal)
S_1
S_2
S_1
S_2
S_4 heart sound


The murmur of mitral stenosis
Mild mitral stenosis
Severe mitral stenosis
Severe mitral stenosis with atrial fibrillation
S_2
S_1
S_2
S_1
S_2
S_1
Opening Snap

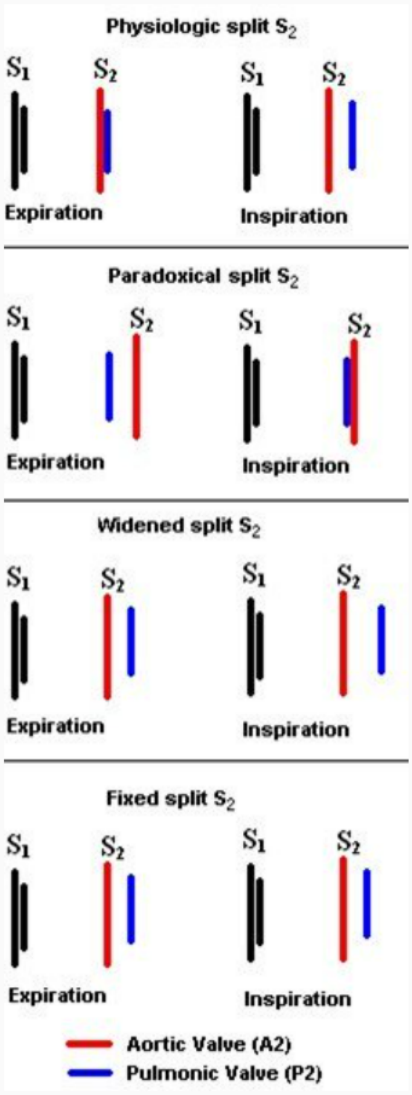

Mitral stenosis
S1
S2
O.S.
S1
Mild
A2
P2
S1
S2
O.S.
S1
Severe
A2
P2
Systole
Diastole


Normal heart without split S_1
S_1
S_2
Normal heart with split S_1
or
RBBB causing a split S_1
S_1
S_2
LBBB causing synchrony of M1 and T1 resulting in absence of split S_1
S_1
S_2
Mitral Valve (M1)
Tricuspid Valve (T1)

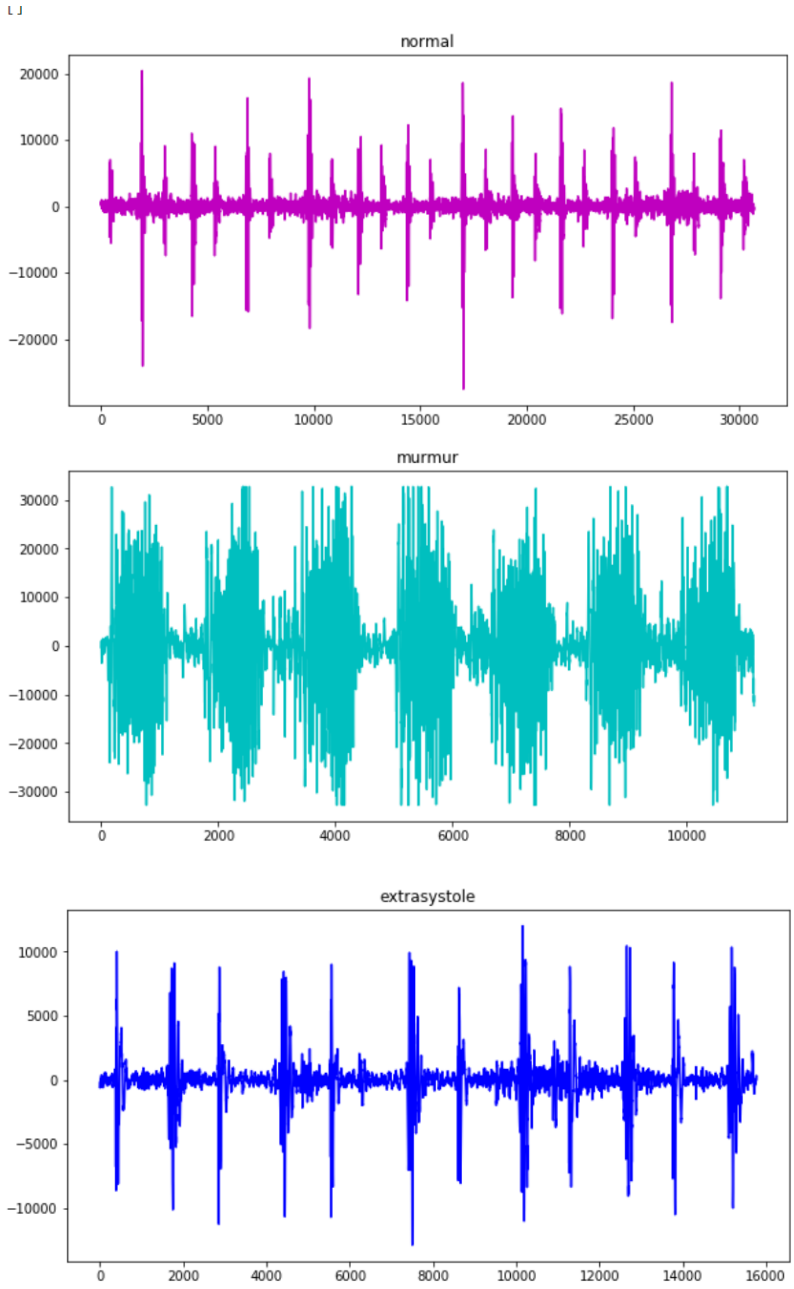
Second Heart Sound (S2)

The second heart sound is produced by the closure of the aortic and pulmonic valves. The sound produced by the closure of the aortic valve is termed A2, and the sound produced by the closure of the pulmonic valve is termed P2.

The A2 sound is normally much louder than the P2 due to higher pressures in the left side of the heart; thus, A2 radiates to all cardiac listening posts (loudest at the right upper sternal border), and P2 is usually only heard at the left upper sternal border. Therefore, the A2 sound is the main component of S2.



So the general main categories of heart sound signals is just the three bellow categories:



References:

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https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9348924/

https://www.kaggle.com/code/mychen76/heart-sounds-analysis-and-classification-with-lstm

https://depts.washington.edu/physdx/heart/demo.html