What is heart failure?

Heart failure is a disease where the heart is unable to pump blood as fast and strong as it needs to get enough oxygen out to the rest of the body. There is yet no cure, but it can be treated. The most common treatment today was developed in the 1970's, and have not changed much since then, even though this disease is the most common cause of death in the western world today.

Mathematical models can be used to unlock the secrets of how fetuses react to adrenalin, and this can help us develop new medication to treat a failing heart later in life.

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Using computers to treat heart failure

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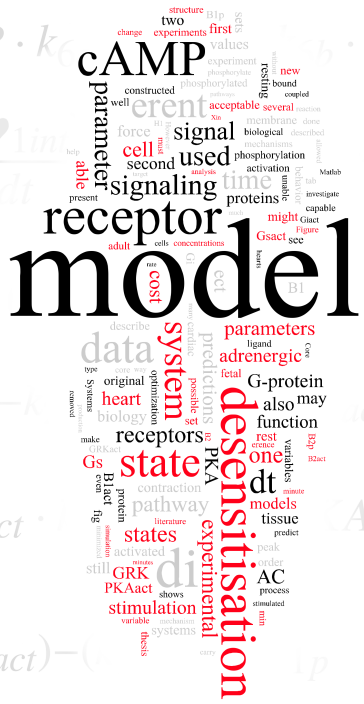

Adrenalin makes the heart beat faster and stronger

When we are excited or scared our bodies release adrenalin, a hormone that makes our heart beat stronger and faster. This way our muscles get more oxygen, for occasions when we need them to work hard.

β-adrenoceptors can sense adrenalin

The molecules in the heart that sense the adrenalin are called β-adrenoceptors. They trigger a chain reaction in the cell, where many different proteins cooperate to make the heart work harder. After a while the heart grows tired, stops reacting to the adrenalin and slows down. Even if the adrenalin is washed away and new adrenalin is added shortly after, the heart will not react. Interestingly enough, the heart does not grow tired in the same manner in fetuses.

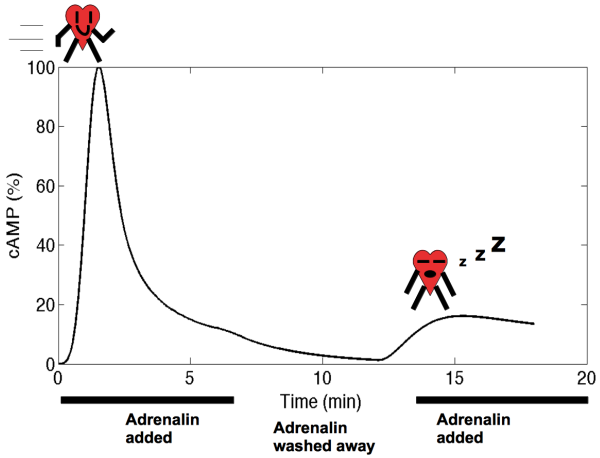

Figure 1: After a while, the adult heart stops reacting to adrenalin. This becomes a problem in heart failure, where we need it to pump more blood to the tissues.

Mathematical models can tell us how the signal travels in the cell

No one has yet been able to pinpoint exactly what the difference is between the adult and the fetal heart when it comes to adrenalin signalling. To investigate this we have made a computer model of the β-adrenoceptor chain reaction. It predicts how long the heart needs to rest to start reacting to adrenalin again and shows us how the different proteins in the cell cooperate.

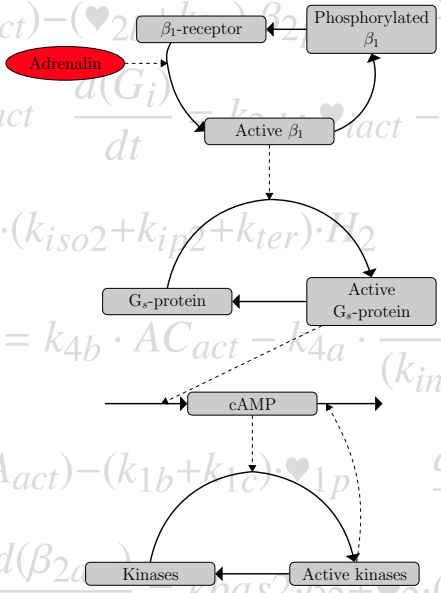

Figure 2: This is a flow chart of the model that we use to predict how the heart reacts when we stimulate it with adrenalin.

Hopefully, the results from this model can be used to find better treatments in diseases such as heart failure. It will also give us valuable new knowledge of how the heart develops from fetus to adult.

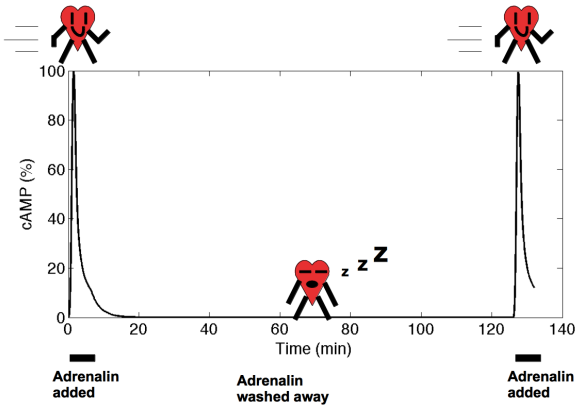

Figure 3: If the heart is allowed to rest long enough between stimulations, it will start reacting again. The mathematical model will tell us why the fetal heart does not need to rest the way the adult heart does. This will help us develop new and better medication to help patients with heart failure.