Applied Physiology Lecture 4/grade 2 Cardiac Output of The Heart

Dr. Mariam Al-Ashbal
MBChB
MSc of Community Medicine

Cardiac output

- Cardiac output is the amount of blood pumped out of each ventricle per minute.
- Cardiac output=stroke volume * heart rate, CO=SV*HR (ml/min)
- Average heart rate=70 beat/minute
- Average stroke volume =70-80 ml/beat
- Average cardiac output= 5000 ml/minute
- Cardiac output varies widely with the level of activity of the body

Factors affecting cardiac output

1. Heart rate: When the heart rate increases, cardiac output increases. Any factor changing cardiac output will also change CO.
2. Heart force: When the heart's force of contraction increases, stroke volume increases, and cardiac output increases.
3. blood volume: when blood volume increases, cardiac output will increase.
4. venous return.
5. Stroke volume

Stroke volume

- Is it the volume of blood pumped out of each ventricle per beat or contraction. As the stroke volume increases, the cardiac output also increases.
- Stroke volume depends upon End diastolic volume and contractility
- SV=EDV-ESV
- The stroke volume for each ventricle is generally equal; Both are approximately 70 ml in a healthy 70 kg man.
- Men, on average, have higher stroke volume than women due to the larger size of their hearts.

Regulation of stroke volume

Three variables regulate it:

- End diastolic volume(EDV): The volume of blood in the ventricle at the end of diastole, sometimes called preload. Stroke volume will increase with increased EDV.
- Total peripheral resistance: frictional resistance in the arteries, inversely related to stroke volume, called afterload.
- contractility: strength of ventricular contraction, stroke volume increase with contractility.

Venous Return

End-diastolic volume is controlled by factors that affect Venous return: first, total blood volume and second, venous pressure (driving force for blood return)

Factors in Venous return:

1. Pressure difference between arteries and veins
   (about 10mmhg)
2. There is a difference in the pressure in the venous system; the highest pressure is in
   the venules, whereas the lowest pressure is in the vena cava into the Rt atrium.
3. Sympathetic nerve activity to stimulate smooth muscle
   contraction and lower compliance.
4. Pressure difference between abdominal and thoracic
   cavities (respiration).
5. Blood volume.

Physiological variation of cardiac output

- Age: cardiac output is higher in adults than in children because blood volume is higher.
- Gender: cardiac output is higher in males than females.
- Altitude: cardiac output increases at high altitude places.
- Pregnancy: cardiac output increases during pregnancy.
- Exercise: cardiac output increases during exercise.
- Emotions: cardiac output increases during emotional expressions

Pathological variation of cardiac output

Pathological causes that increase CO are:

- Hyperthyroidism.
- Fever.

Pathological causes that decrease CO are:

- Hypothyroidism.
- Hypovolemia.
- Hemorrhage.
- Myocardial infarction.

Relationship with BP

As cardiac output is made up of heart rate and stroke volume, these are relatively constant at rest.

With exercise, the heart beats faster- more blood is pumped out with each beat, contributing to a rise in blood pressure.

Changes in blood volume within the cardiovascular

system will also affect BP.

Relationship with BP

A person is severely dehydrated or loses a large quantity of blood through a wound, there would be less blood for the heart to pump to reduce CO and BP.

At the peak of exercise, the cardiac output of a typical fit young person might reach about 20 litres/ min.

The maximum cardiac output for a world-class athlete in an endurance sport might be around 35 litres/min.

Regulation of cardiac output

It means maintaining a constant cardiac output of around 5 litres/min under normal conditions and adjusting the cardiac output per physiological demands.

It must be regulated to have optimum cardiovascular efficiency.

Mechanism of regulation

1. venous return, a muscle fibre's contraction force is proportional to its initial length, known as Starling`s law of muscle contraction.

2. nervous system: The autonomic nervous system plays a significant role in regulating cardiac output. When sympathetic activity increases, it stimulates both the SA node and ventricular myocardium and increases heart rate, force of contraction, and SV. This will, in turn, increase cardiac output. If parasympathetic activity increases and inhibits the SA node, this will decrease heart rate, which will, in turn, decrease CO.

3. Hormonal regulation of cardiac output: Whenever the adrenaline level in the blood increases, it stimulates the SA node and ventricular myocardium, which increases both heart rate and stroke volume, which, in turn, increases cardiac output.

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Limitations for the cardiac output

There are definite limits to the amount of blood that the heart can pump, which are quantitatively expressed in the form of cardiac output curves.

- Regular: the plateau level of this standard cardiac output curve is about 13 L/min.
- Hypo-effective: The lower curves are for hypo-effective hearts that are pumped at a level below normal, about 5 l/min.
- Hypereffective: uppermost curves that are pumping better than normal its about 20 L/min

Thank you