Photoplethysmography (PPG)

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Photoplethysmography (PPG) is a simple optical technique used to detect volumetric changes in blood in peripheral circulation. It is a low cost and non-invasive method that makes measurements at the surface of the skin.

The technique provides valuable information related to our cardiovascular system. Recent advances in technology has revived interest in this technique, which is widely used in clinical physiological measurement and monitoring.

Principle of PPG

PPG makes uses of low-intensity infrared (IR) light. When light travels through biological tissues it is absorbed by bones, skin pigments and both venous and arterial blood.

Since light is more strongly absorbed by blood than the surrounding tissues, the changes in blood flow can be detected by PPG sensors as changes in the intensity of light.

The voltage signal from PPG is proportional to the quantity of blood flowing through the blood vessels. Even small changes in blood volume can be detected using this method, though it cannot be used to quantify the amount of blood.

A PPG signal has several components including volumetric changes in arterial blood which is associated with cardiac activity, variations in venous blood volume which modulates the PPG signal, a DC component showing the tissues' optical property and subtle energy changes in the body.

Some major factors affecting the recordings from the PPG are site of measurement and the contact force between the site and the sensor.

Blood flow variations mostly occur in the arteries and not in the veins.

The PPG Waveform

PPG shows the blood flow changes as a waveform with the help of a bar or a graph. The waveform has an alternating current (AC) component and a direct current (DC) component.

The AC component corresponds to variations in blood volume in syncronization with the heart beat. The DC component arises from the optical signals reflected or transmitted by the tissues and is determined by the tissue structure as well as venous and arterial blood volumes.

The DC component shows minor changes with respiration. The basic frequency of the AC component varies with the heart rate and is superimposed on the DC baseline.

Uses of PPG

Medical devices based on PPG technology are widely used in various applications in the clinical set up.

Specific applications include the following:

- Clinical physiological monitoring
- Blood oxygen saturation
- Blood pressure
- Cardiac output
- Heart rate
- Respiration
- Vascular assessment
- Arterial disease
- Arterial compliance and ageing
- Venous assessment
- Endothelial function
- Microvascular blood flow
- Vasospastic conditions
- Autonomic function monitoring
- Vasomotor function and thermoregulation
- Blood pressure and heart rate variability
- Orthostasis

- Other cardiovascular variability assessments

Wearable Devices

Using this technology, wearable pulse rate monitors have been developed. These low-cost and small devices have high-intensity green light-emitting diodes (LEDs) and photodetectors that help reliable monitoring of the pulse rate in a non-invasive manner.

Important design requirements for these systems include miniaturization, robustness and user-friendliness.

These devices have a sensor that monitors minor variations in the intensity of light transmitted through or reflected from the tissue. These intensity changes are associated with changes in blood flow through the tissue and provide vital cardiovascular information such as the pulse rate.

Other Systems

PPG has been used in other technologies such as telemedicine, PPG imaging technology and remote monitoring.

Researchers have studied skin blood flow and the related rhythms using a near infrared CCD PPG imaging system. This study aimed at obtaining fresh insights into biological tissue perfusion and studying changes associated with wound healing and formation of ulcers.

Other studies have applied PPG in remote imaging of the distribution of arterial oxygen saturation (SpO2) within a tissue. Such an image might be valuable in medical diagnostics studies such as quantification of tissue viability. In telemedicine, PPG is promising in remote monitoring of patients' health.

Reviewed by Yolanda Smith, BPharm

References

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Further Reading

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