

## ECG measurement protocol

### General information

An electrocardiogram measures the electrical activity of the heart muscle.

- ECG is measured in millivolt [mV];
- The ECG signal is usually between 1 and 5 mV.

### Equipment needed:

- ECG equipment;
- 3 disposable electrodes (Ag/AgCl);
- Scrub gel (NuPrep);
- Cotton buds/cotton wool pads;
- Gloves;
- Alcohol wipes.



### Cleaning/preparation

**Important:** Always wear disposable gloves when you clean the participant's skin, apply the electrodes, and disconnect the participant. After use, always remove the gloves and dispose of them.

It is important to reduce the impedance (resistance) of the skin before applying the electrodes, by removing oils and dead skin cells. It is recommended to use a scrub gel (NuPrep). The gel is gently rubbed on the skin with a cotton bud or pad. Afterwards, the skin is dried with a clean cotton pad. Apply the electrodes directly after cleaning the skin.

### Placing the electrodes

**Important when using Biopac devices:** when attaching the leads, you must squeeze the plastic lock connector at the end of the lead. When disconnecting the leads, squeeze the lock connector again. Never pull on the lead itself. This material is very fragile and breaks easily. Similarly, when the leads need to be attached to or detached from the wireless module, you should use the plastic squeezable connector and refrain from pulling on the leads. Afterwards, loosely coil the leads and tuck them into the appropriate pocket. Do not knot or twist the leads, as it may damage them.

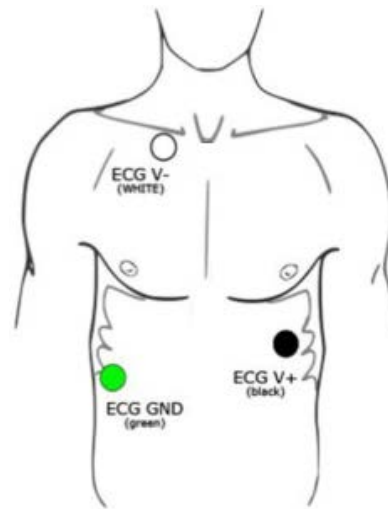
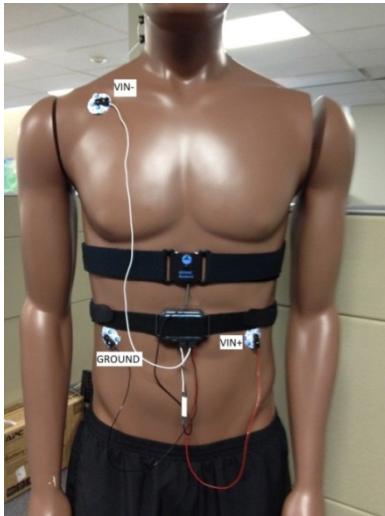
**Important:** Apply the electrodes 5 to 10 minutes before you start measuring.

The number of electrodes used and their placement can differ depending on the type of study. A common method is to use three electrodes, one of which is placed under the right collarbone (negative, V-), one on the left on the bottom rib (positive, V+), and one on the right just below the ribs (grounding).

Which leads (specifically: which colour) should be attached to these electrodes depends on the system that you are working with. With the Biopac system, you should attach the black lead to the grounding electrode on the right, below the ribs. The red lead should be attached to the electrode on the left, on the ribs, and the white lead to the electrode on the right, below the collarbone. When using the wireless Biopac module, you can fix the strap with the transmitter around the participant's waist and then attach the leads to the electrode. Ensure the strap is placed between the Biopac transmitter and the skin, so that the transmitter does not come into contact with the skin.

With the VU-AMS system, you attach the green lead to the grounding electrode on the right, below the ribs. The black lead should be attached to the electrode on the left, on the ribs, and the white lead to the electrode on the right, below the collar bone.

In both systems, the heart should be in the centre of a line drawn from the positive to the negative electrode. The ground electrode must never be placed between these two!



### Biopac

VU-AMS – Figure adapted from source: Nederend, ten Harkel, Blom, Berntson, & de Geus, 2017

### Afterwards

Remove the leads and, if present, the wireless module. The participant can then remove the electrodes him/herself. Removing the electrodes can be painful for some people. Depending on the sensitivity of the participant's skin, there may be red marks visible. These will normally fade within a few hours. Give the participant a tissue to remove any excess gel, or allow the participant to wash the areas in question with water and soap. The electrodes can be discarded in the bin. After each participant the equipment he/she has been in contact with must be cleaned. This could apply to the leads that were attached to the electrodes and, in the case of the wireless Biopac module, the transmitter. Clean these components carefully with an alcohol wipe. Ensure that no liquids enter the equipment. The strap must be cleaned after use with Incidin Plus.

### Tips to ensure usable data

- Check whether the electrodes and leads are attached properly;
- The participant must move as little as possible to prevent artefacts in the data;
- The participant must be comfortable and sit in a natural posture with both feet on the floor;
- When the data looks irregular or shows a flat line, check whether the leads are properly attached and whether the electrodes are still properly attached;
- If the data looks upside down (i.e., when the R peaks are pointing down) it is likely that the V+ and V- leads have been swapped around. Check whether the V- lead is attached to the electrode under the collarbone and the V+ lead to the electrode on the left-hand side below the bottom rib.

### Literature

Nederend, I., ten Harkel, A. D. J., Blom, N. A., Berntson, G. G., & de Geus, E. J. D. (2017). Impedance cardiography in healthy children and children with congenital heart disease: Improving stroke volume assessment. *International Journal of Psychophysiology*, 120, 136-147.