Current distribution under electrodes in relation to stimulation current and skin blood flow: are modern electrodes really providing the current distribution during stimulation we believe they are?


Author information

Abstract

Carbonized rubber electrodes were tested extensively when they were first developed 30 years ago, but modern carbonized rubber electrodes have not received the type of scrutiny that the first electrodes received. Modern electrodes differ from the original electrodes in that they come with a self-adhesive electrode gel called hydrogel as part of their composition. The present study was undertaken to examine the current distribution and impedance characteristics of five brands of carbonized rubber electrodes and to examine the current distribution between electrodes during electrical stimulation in six subjects. Several different electrode sizes were tested between 3 and 10 cm. The current flow between the electrodes was determined by measuring the voltage across the skin on human subjects in 15 discrete locations between the electrodes. Blood flow was also measured between the electrodes with a laser Doppler flow meter to assess the physiological effect of current distribution on the skin at several skin temperatures. The results of these studies showed that at low currents, such as is used in TENS, very little current is actually applied through the skin due to the high impedance of the electrodes. At current levels normally used for electrical stimulation for functional movement, while current flow is better in most electrodes, it is very uneven, resulting in high current density in the centre of the electrodes and a fall off of at least 50% in current intensity at the edges of the electrode. There was very little difference in current density between small and large electrodes due to the high current density in the centre. Skin blood flow altered the movement of current between the electrodes and also may contribute to electrode performance. The implication of these studies is that electrode design needs to be altered for better current distribution, especially at low stimulation currents.