

Comparison of ECG Signal Quality between a Novel Dry Electrode and a Standard Gel Electrode

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Abstract

BACKGROUND: Electrocardiography has an important role in diagnosis and monitoring of patients. Surface electrodes relay signals from the patient to the electrocardiograph device. Traditionally gel based electrodes are used to transmit the electrical signal. However, gel electrodes are inconvenient because they require aggressive skin preparation and use an electrolytic solution to ensure electrocardiograph (ECG) quality. The purpose of this study was to compare the reliability and signal quality of traditional gel electrodes with a novel dry electrode that requires no abrasive skin preparation or electrolytic solution. The dry electrode is designed with micro-anchors that may penetrate the SC layer of skin. The micro-anchors are intended to reduce motion artifact, increase patient comfort and maintain signal quality relative to traditional electrodes. The sensing element, housing and snap are monolithic polymer plated with Ag/AgCl- for conductivity. A novel adhesive scheme is used to maintain the dry electrode skin interface. The tape is clear, flexible and breathable. **SUBJECTS:** Eleven apparently healthy subjects consisting of 6 males and 5 females volunteered as subject (30.25 +/- 7.8 years). All subjects signed a consent form approved by the Cleveland State University Institutional Review Board. **METHODS:** Resting and exercise ECGs were obtained using standard ECG telemetry equipment (ScottCare TeleAdvantage System-Cleveland, Ohio). Subjects were tested on two consecutive days, wearing either the novel dry electrode or the standard 3M Red dot electrode in a lead II configuration. The electrode testing was done in randomized sequence. Data was collected while supine, standing and during a sub-maximal Bruce protocol (GXT). ECG signals for the entire data set were collected at 120 Hz and were analyzed using the Matlab 6th order Debauchy wavelet technique to de-noise the traces and establish a signal to noise ratio. **RESULTS:** A two tailed paired t-test was performed on the signal to noise ratios to compare the signal quality of the two types of electrodes. The mean signal-to-noise ratio was 16.33 (±2.68) for the standard gel electrode and 17.29 (±2.06) for the dry electrode with a non-significant difference (P value of 0.2573). **CONCLUSIONS:** It was concluded that the novel dry electrode provided signal quality that was comparable to the standard gel electrode without the need for skin preparation or electrolytic solution. The novel dry electrode may be a suitable alternate to gel based electrodes for the ECG studies. Additional studies are pending to exploit the fidelity of the novel dry electrodes in more chronic applications.

Introduction

Surface electrodes relay signals from the patient to the electrocardiograph device. Traditionally, gel based electrodes are used to transmit the electrical signal. However, gel electrodes are inconvenient because they require aggressive skin preparation and use an electrolytic solution to ensure electrocardiograph (ECG) quality. Many efforts have focused on developing an alternative technology to be used for long duration bio-potential studies for ECG monitoring. As far back as the 1960's scientists and engineers attempted to develop dry electrodes for ambulatory studies.¹⁻³ Orbital Research Inc. (Cleveland, Ohio - ORI) has developed a disposable dry electrode (Figure 1, Figure 2). The success of the technology is largely due to surface micro-structures that function as the sensing element of the electrode. These micro-features augment the electrode/skin interface by mechanically connecting the skin and the electrode, thus facilitating the transmission of the ECG signals from the body through the electrode and reducing motion artifact.



Figure 1 Photo Graph of the Novel Dry Electrode



Figure 2. Dry Electrode in place on the skin

Purpose

The purpose of the study was to compare the ECG signal quality of a novel dry recording electrode to the signal quality of a standard gel based electrode during graded exercise testing.

Methods

A repeated measures design was used to test the hypothesis stating no differences in signal quality using the novel dry electrode when compared to a standard gel electrode during graded exercise testing. Eleven healthy subjects (6 males, 5 females) were telemetrically monitored using the Scott Care Tele Rehab (Cleveland, Ohio) system during a standard Bruce treadmill protocol. The subject's age ranged from 21 to 43 years. All subjects followed the protocol until they reached 85% of predicted maximum heart rate.

The novel dry ECG electrode technology was compared to the standard 3M Red Dot electrode. The electrodes were tested in random sequence on consecutive days. A permanent marker was used to mark the skin prior to the first trial to ensure consistency of electrode placement. The 3M Red Dot™ (a gel-based traditional electrode) or the Orbital Research dry electrode was placed in a LEAD II configuration, without any skin preparation.

Signal was collected at 120 Hz during each trial. The data was analyzed in Matlab™ (The MathWorks Inc. Natick, MA) using a 6th order Debauchy wavelet technique to de-noise the traces (Figure 3) and establish a signal-to-noise ratio for each electrode style, mean signal-to-noise ratios (dB) were calculated and comparisons were made using a paired t-test, at a significant level of 0.05.

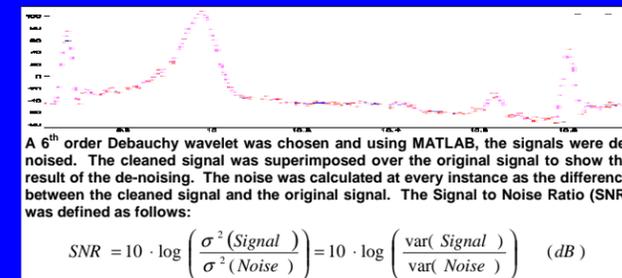


Figure 2. A 6th order wavelet technique.

Results

The signal quality of the two types of electrodes (Table 1) indicated a mean signal to noise ratio was 16.33 ±2.68 for the standard gel electrode and 17.29 ±2.06 for the dry electrode with a non-significant difference (P value of 0.2573). Individual subject results (Figure 4) show variability between the two electrodes between and among subjects.

COLUMN STATS	RED DOT™	ORI
Number of values	11	11
Minimum	11.84	13.66
25% Percentile	15.09	15.68
Median	16.79	17.21
75% Percentile	18.09	19.39
Maximum	20.76	20.69
Mean	16.33	17.29
Std. Deviation	±2.68	±2.06
Std. Error	0.80	0.62
Passed normality test (alpha=0.05)?	Yes	Yes

Table 1. Signal-to-noise ratio (dB) values.

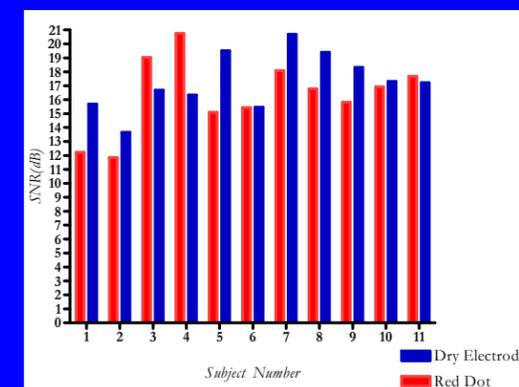


Figure 4 Within Subject Comparison of Signal to-to-noise ratio (dB)

Summary and Conclusion

It was concluded that the novel dry electrode provided signal quality that was comparable to the standard gel electrode without the need for skin preparation or electrolytic solution. The novel dry electrode may be a suitable alternate to gel based electrodes for the ECG studies. Additional studies are pending to exploit the fidelity of the novel dry electrodes in more chronic applications.

Acknowledgements

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References

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