Rx FOR ECG MONITORING ARTIFACT

By Michael Smith, M.S., B.S.E.E.

Introduction

The object of electrocardiographic (ECG) monitoring is the observation and assessment of the heart's electrical activity. Cardiac monitoring has become extremely commonplace in recent years in critical care and ambulatory settings. Electronic advancements have produced instrumentation with the potential of providing accurate information and reliable heart rate alarms. Computerized monitors enhance patient assessment by allowing uninterrupted electronic observation of heart rate and ectopic activity with comprehensive automatic reporting mechanisms. Despite these improvements in instrumentation, monitoring systems continue to be plagued by problems related to poor signals. Wandering baselines, small complexes, fuzzy tracings, and frequent electrode replacement make patient assessment difficult and induce false heart rate alarms. Improvement in electrode preparation techniques and a better understanding of the sources of artifact can enhance equipment performance, resulting in improved patient assessment, more effective utilization of nursing time, and reduced operating costs. This article discusses the physiologic and non-physiologic sources of ECG monitoring artifact and presents a method of electrode site preparation to reduce artifact.

Sources of ECG Monitoring Artifact

The electrical activity of the heart is sensed by monitoring electrodes placed on the skin surface. The electrical signal is very small (normally 0.0001 to 0.003 volt). These signals are within the frequency range of 0.05 to 100 Hertz (Hz.) or cycles per second. Unfortunately, other artifactual signals of similar frequency and often larger amplitude reach the skin surface and mix with the ECG signals.[9,12] Artifactual signals arise from several internal and external sources. Internal or physiologic sources of artifact are: (1) signals from other muscles (electromyographic signals) and (2) signals produced in the epidermis. External or non-physiologic sources of artifact are: (1) 60 Hz. Pickup, (2) offset signals produced by the electrode itself, (3) signals produced by the interaction of body fluids and the electrode gel, and (4) lead wire and patient cable problems.

Physiologic Sources of ECG Artifact

Electromyographic (EMG) Signals - All muscle activity produces electrical signals. Signals from muscles other than the heart are called EMG signals and appear on the monitor as narrow, rapid spikes associated with muscle movement. These signals are sufficiently dissimilar to the ECG signals that they can be electronically reduced or "filtered" from the trace. This filtering is readily observed by reduction in the size of EMG signals as the monitor is switched from the diagnostic mode to the monitor mode (in monitors so equipped).

Epidermal Signals - The skin is a source of electrical signals which produce motion artifact. Studies have revealed that a voltage of several millivolts can be generated by stretching the epidermis, the outer layer of the skin.[4,5,8,10,11,12] This stretching is the primary source of movement-related (motion) artifact.12 This type of artifact is visible as large baseline shifts occurring when the patient changes positions in bed, eats or ambulates. Epidermal artifact is more troublesome than other types of artifact because: (1) it is difficult to filter electronically and (2) its amplitude is often larger than the ECG signal.[12]

Non-Physiologic Sources of ECG Artifact

60 Hz. Pickup - This type of artifact, also called 60 Hz. Interference, produces a wide, fuzzy baseline. It is related to poor electrode contact associated with poor skin preparation techniques, dried electrode gel, or defective patient cables or lead wires.

The source of 60 Hz. pickup is the 60 Hz. current which supplies power to the electrical wall outlets. The 60 Hz. energy "radiates" from the electrical wiring in the patient's room and is received in the lead wires and by the patient. The source of radiation cannot be eliminated, but modern monitors can reduce 60 Hz. pickup by filtering and by an electronic technique called **common mode rejection**. This technique requires good skin contact by **all** electrodes. One or more electrodes with poor contact will result in the wide fuzzy baseline.

Offset Potentials - An offset potential is a voltage that is stored by the electrode. This stored voltage will add to the ECG signal and interfere with it. (The offset potential causes the disappearance of the ECG after defibrillation.) The amount of offset potential and the length of time required for it to dissipate are determined by the materials used for the electrode and the gel. Certain combinations of metals and gels generate large voltages (up to 200 millivolts) with the ability to hold this voltage for long periods of time. Electrode materials such as silver-silver chloride do not allow significant buildup of offset potential, whereas stainless steel electrodes have poor offset characteristics. Most electrodes used for ECG monitoring today are made of silver-silver chloride. With the common use of the silver-silver chloride electrode, offset potentials are no longer considered to be a significant problem.

Electrode Gel - until recently, movement of the electrode gel under the electrode was thought to be the primary cause of motion artifact; however, studies have revealed that this effect is minimal.[8,12] The electrode gel does, however, significantly affect the transmission of signals from the skin to the electrode. The lack of sufficient electrode gel, frequently due to evaporation caused by improper storage, results in 60 Hz. pickup and extremely unstable traces. This type of artifact is easily identified by very high electrode impedances (discussed below).

Lead Wire and Cable Problems - Breaks in the wires and connections between the electrode and the monitor will always be a source of monitoring problems. Poor contact at any snap connection, loose pins at the cable end of the lead wire, and breaks in the conductors of the lead wire or patient cable can cause intermittent loss of the ECG tracing, 60 Hz. pickup, or trace instability.

Electrode Impedance

In order for ECG signals to pass from the body to the electrode, an electrically conductive path between the skin and electrode must be established. The conductive ability of this path is referred to as **electrode impedance** or **contact impedance**. Electrode impedance is measured in ohms. High impedance decreases the conduction of the ECG signal. Low impedances improve this conduction. The major factors affecting electrode impedance are: (1) the quantity and quality of gel between the electrode and the patient and (2) the degree to which the outer layer of the epidermis (the stratum corneum) has been bridged by the conductive gel.

Proper site preparation (as described below) will produce contact impedances of 10,000 ohms or less in 90% of patients.[9] Less than 5,000 ohms is a good target value. Improper site preparation will usually produce contact impedances as high as 100,000 to 200,000 ohms.

Interventions to Reduce ECG Artifact

To obtain good monitoring tracings, the ECG signal must be as large as possible and the artifact signals as small as possible. Proper preparation of the site is required to accomplish these goals. A brief review of the anatomy of the skin can aid in understanding the rationale for the steps of skin preparation.

The skin is composed of the epidermis, the outer layer, and the dermis, which lies beneath the epidermis. The epidermis contains three layers: (1) the **stratum germinativum**, which is the bottom layer and the layer where epidermal cells originate; (2) the **stratum granulosum**, the middle layer and the layer where epidermal cells mature, function, and begin to degenerate; and (3) the **stratum corneum** or "horny layer", the outer layer. The stratum corneum contains flat, dry, deal cells which do not conduct electricity well. These cells can significantly affect the transmission of the ECG signal from the skin to the electrode (i.e., electrode impedance). The stratum granulosum is the layer from which motion artifact is generated. Both the stratum corneum and the stratum granulosum must be prepared properly to achieve good tracings. (See steps one and two below).

Remembering these structural components of the skin, one can appreciate the necessity for adequate site preparation. An ideal skin prep consists of four steps:

1. removal of part of the stratum corneum to allow the electrical signals to travel to the electrode.
2. scratching the stratum granulosum to reduce motion potentials generated in this layer.
3. defatting the skin to permit the adhesive base on the electrode to grip the skin.
4. assuring the presence of conductive gel.

Step One: Removal of Part of the Stratum Corneum - A variety of methods can be used to remove part of the outer epidermal layer. Vigorous rubbing with a gauze pad, abrading with a rough surface, or gentle abrasion with a sharp material are accepted techniques. The most effective, practical method is gentle abrasion using fine (waterproof) sandpaper, such as 320 to 400 grit wet or dry paper. Such sandpaper is a component of at least one brand of electrode (3M Red Dot). Packaged electrode gels containing sharp, gritty material (such as OmniPrep) also serve this purpose extremely well and should be considered where electrodes without the sandpaper prep are used.

The advantage of the sandpaper and the gritty gel method over the other methods is that it removes the unwanted, nonconductive deal cells, with minimal skin damage or irritation. Five to ten gentle strokes can effectively decrease impedance while barely reddening the skin. The contact or electrode impedance can be reduced from 100,000 - 200,000 ohms to 1,000 - 5,000 ohms with this simple technique. Additional benefits are reductions in 60 Hz. pick up and some reduction in motion artifact.

Step Two: Scratching the Stratum Granulosum - Fine scratches in the stratum granulosum can be made by the sandpaper and the gritty gels as described above, however, rubbing with gauze pads or rough surfaces has little or no effect on this layer other than to cause irritation. Fine scratches produced by the sandpaper or grit allows the conductive gel to penetrate the stratum granulosum and "short circuit" the epidermal potentials responsible for motion artifact. Five to ten gentle strokes of 220 or 400 grit wet or dry sandpaper or gentle rubbing with a gritty gel can significantly reduce contact impedance and motion artifact.

Step Three: Defatting the Skin - Rubbing the skin with an alcohol gauze pad is an acceptable method to remove skin oils. Although acetone is used often instead of alcohol, alcohol is preferred because it provides an adequate degree of fat removal while minimizing skin irritation. Acetone is more irritating to the skin and tends to produce **higher** contact impedances than alcohol.[8] In addition, acetone presents a fire hazard because it is so highly flammable.

Step Four: Assuring the Presence of Conductive Gel - A dry electrode which does not have adequate conducting gel will not work. Although bad batches of electrodes occasionally are received from a manufacturer, most instances of electrode gel dry-out are related to incorrect storage. Electrodes are packaged in metal foil wrappers which are highly impervious to moisture. These wrappers, which help to prevent evaporation of the gel, should not be removed until the electrode is to be used. Electrodes should not be placed in open bins or drawers, and care should be taken to avoid warm storage areas. The electrodes should **always** be examined for adequate gel prior to application. Electrode stocks should be rotated so that electrodes are used prior to the expiration date, which is usually stamped on the shipping box and the individual package. Packages which contain dried out electrodes, yet are within the expiration date should be returned immediately to the vendor for credit and to alert them to the possibility of a manufacturing problem.

Conclusion

Artifact in ECG monitoring can be annoying, costly, and dangerous. An understanding of the sources of artifact and care in the application of monitoring electrodes can significantly reduce or even eliminate the problem. Review the sources of artifact and the four-step method for applying electrodes with your staff and continuing education department. You might be pleasantly surprised to see just how good your ECG tracings can become.

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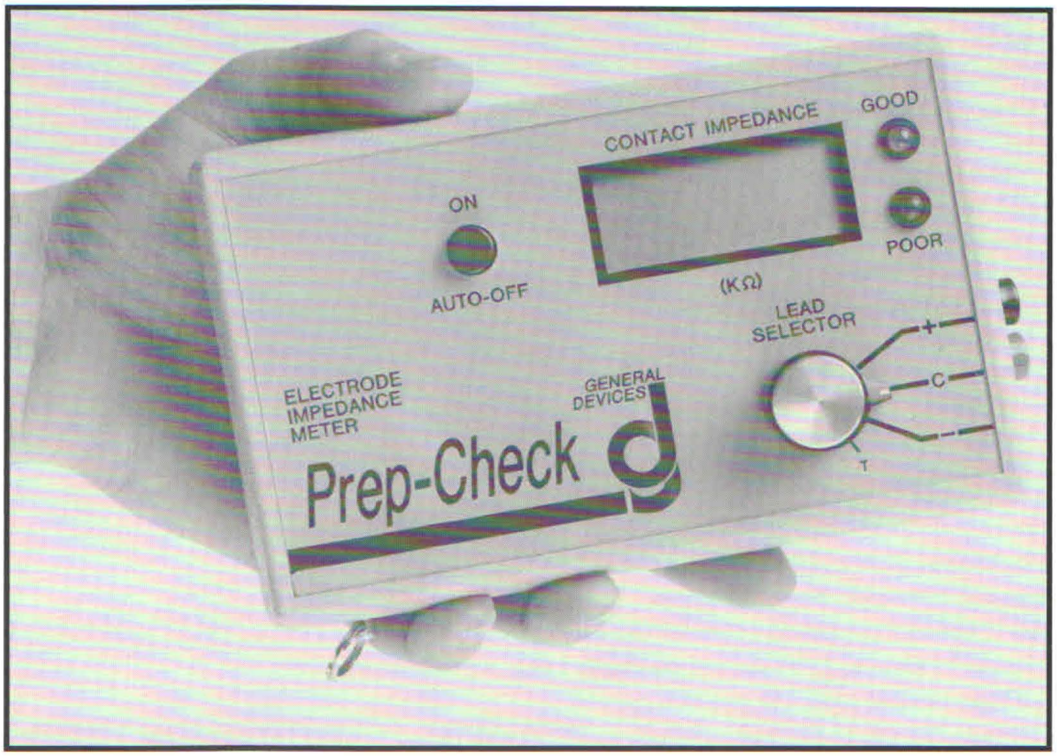
General Devices PREP-CHECK Electrode Impedance Meter



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