Acquiring the 12-lead Electrocardiogram: Doing It Right Every Time

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The electrocardiogram (ECG) is a ubiquitous, noninvasive procedure used extensively in diagnostic cardiology. The purposes of the acquisition of an ECG are varied, from bedside monitoring to ambulatory event monitoring. In the emergency department, the 12-lead ECG is the initial test for the patient with chest discomfort or any other acute coronary syndrome (ACS), and it must be obtained within 10 minutes of patient arrival according to established standards. In the United States, the incidence of a new myocardial infarction (MI) is approximately 610,000 annually, and the recurrence rate of a subsequent MI is approximately 325,000 per year.[1] In this context, the ECG becomes an invaluable tool for the rapid identification of a patient undergoing a cardiac event. Subsequently, the interpretation of an ECG may identify patients who need to go to the catheterization laboratory for emergent reperfusion through a percutaneous coronary intervention (PCI) or, if PCI is unavailable or contraindicated, the administration of thrombolytics. Considering this degree of importance, why are nurses not provided adequate training on accurately obtaining 12-lead ECGs? Many essential nursing skills have been relegated to "on-the-job" training, but if the trainer/preceptor never learned proper form, the trainee is subjected to improper techniques and a vicious cycle is created. This article will focus exclusively on properly acquiring a 12-lead ECG in the ED setting for a patient with cardiovascular symptoms.

Why is the ECG Clinically Important?

In a systematic review of 10 studies, Khunti[2] found that nurses had limited knowledge and skills in the correct placement of electrodes; they commonly misplaced electrodes because of a reliance on a "visual" approach.[3] With this in mind, it is important to note that several sources have documented ECG abnormalities due to various operator factors. Cable misplacement may lead to conduction disturbances that can simulate or conceal myocardial ischemia or MI,[3,4] such as mimicking a lateral-wall MI in a true case of inferior-wall MI.[5] The common practice of placing the limb electrodes on the torso can result in false ST-segment elevation.[6,7] Some or all of the aforementioned scenarios can create a situation in which an ST elevation myocardial infarction (STEMI) is inappropriately identified.

The cost of diagnostic catheterization is often more than $5,000 depending on ensuing hospitalization and critical care. The ramifications of a false-positive identification of a STEMI are also costly for the patient. The patient is exposed to various medications as part of the standard treatment regimen, and if taken to the catheterization laboratory, he or she is exposed to contrast material, which may be nephrotoxic.[3] Despite the frequency with which it is performed, coronary angiography is not an innocuous procedure. It places the patient at potential risk of inadvertent complications from excessive bleeding due to femoral artery puncture, aortic laceration, coronary artery laceration, or induction of an MI. If the patient receives fibrinolytics, he or she is placed at high risk of hemorrhage despite all the pre-administration safeguards. Timely recognition of a STEMI to achieve reduced door-to-balloon or door-to-needle times may come at the risk of false-positive identifications. McCabe et al[8] reported a 36% prevalence of false-positive STEMI activations in ED patients presenting to 2 PCI-capable centers. The subgroup analysis of the same study did not include ECG quality as a factor in determining false-positive activations.

Operator-Related Factors

Orientation of new emergency nurses should include a review of equipment operating instructions provided by the manufacturer. Acquisition of a reliable 12-lead ECG begins with a thorough knowledge of the equipment being used within the emergency department because machines within the emergency department can vary. It is incumbent on the emergency nurse to be familiar with the specifications and limitations of the various devices in use. Each manufacturer has its own proprietary algorithm that is used to decode the

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ECG signal and provide a tracing and interpretation.[9–11] The accuracy of the algorithm is dependent on the operator setting up the test according to specifications so that it may function as intended.[9–11]

FREQUENCY RESPONSE

The *frequency response* is a technical term for "noise" filtering. It is an essential component within the machine circuitry because of the various applications of the ECG. When one is performing bedside monitoring for identification of dysrhythmias or evaluating heart rate, monitor-quality mode is sufficient for this task. This implies that the filter is on and the device is eliminating noise outside the prescribed bandwidth (0.5-40 Hz).[12] Unfortunately, discrete changes in the ST segment will be undetectable in this mode, and it should never be used in the evaluation of ST-segment elevation or depression. Therefore 12-lead ECGs must be obtained in diagnostic-quality mode. In this mode the filter is off and the signal bandwidth is widened (0.5-150 Hz) to identify the finer details.[12] However, there are some drawbacks when operating within the diagnostic-quality bandwidth; movements (eg, breathing or tremors) become accentuated in this mode. In the recorded 12-lead ECG, this can obscure the details that are integral for proper identification. To explain this concept another way, frequency response is like the curtain during a theatrical performance. When the curtain is only partially opened, the viewer's attention is drawn to the specific area the director wants to showcase (monitor quality). When the curtain is opened wide, everything comes into view (diagnostic quality) but that comes at the expense of possible distractions.

DEVICE SETTINGS

Another component of the standard 12-lead ECG revolves around the output of the printed tracing. Calibration of the device is a function that identifies the amplitude of the waveform in relation to the ECG graph paper. The standard is 1 mV = 10 mm and can be verified by the phrase "1×" being printed at the bottom of the ECG tracing.[12] Any setting other than standard calibration will distort ST-segment elevation or depression, as well as other features, such as the identification of hypertrophy. Correct paper speed affects the timing of the ECG with respect to measurement of rate and duration of intervals. The standard paper speed is 25 mm/s, and this will also be printed at the bottom of the ECG tracing.[12] The paper speed can be changed, but this will interfere with the proper identification of heart rate or the measurement of intervals, such as the PR and QT intervals, and QRS width.

For the purpose of quality assurance, the emergency nurse should verify the frequency response, calibration, and paper speed on the printed ECG before delivering the 12-lead ECG to the provider. In addition, the nurse should observe lead aVR to determine if the complexes are positive or negative. Positive complexes in lead aVR with negative complexes in lead I can indicate 1 of 2 conditions—dextrocardia or a possible arm lead reversal, the latter of which is easier to confirm.[13] If any of the aforementioned items are not according to standard, a new tracing must be obtained.[12]

CABLES

The devices used in the emergency department are subject to extreme amounts of use, and as such, problems related to wear may be present. Similar to electrical extension cords, ECG cables are covered in rubberized material that shields the transmission of the signal. If this coating becomes worn, there could be a loss of signal to one, some, or all channels (leads). Interference can also be a factor that leads to artifacts in the ECG signal.[12,13] When a tracing has excessive artifacts, a change in patient cables or electrodes may be necessary. Therefore the emergency nurse should examine the ECG cables on a regular basis to ensure that they are not worn and are still suitable for patient use.

PATIENT DATA PROGRAMMING

The ECG is part of the patient's comprehensive medical record and will be stored for possible retrieval in the future. To preserve the ECG for the purpose of cataloging serial test findings, information such as patient name and medical record number will need to be entered into the device. In addition, the device requires minimum data input of age and sex to apply the correct algorithm to the analysis of the ECG.[9–11] In the absence of this crucial information, the device will "default" to the settings for an adult male patient. As such, the software will analyze incorrect data, possibly yielding an erroneous interpretation, especially in the case of women or pediatric patients. The emergency nurse needs to remember that, at its core, the ECG machine is operated by a computer processor and failure to adhere to the basic manufacturer recommendations may result in an inaccurate end product. As is said in the computer industry, garbage in equals garbage out (GIGO).

Patient-Related Factors

SKIN PREPARATION

The electrode is the interface between the device and the patient. Because the skin itself is a poor conductor of