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The 12-lead electrocardiogram (ECG) is one of the most commonly performed investigations in acute areas of care, and is the cornerstone of cardiac investigation. Its uses include the diagnosis of arrhythmias and myocardial infarction, as well as the evaluation of cardiac chamber size and ion channel function. Abnormalities in electrolyte balance, the effects of drug therapy, and acute events involving the lungs or brain may also be evident on the 12-lead ECG. To assess these conditions accurately, a high quality recording is essential. This means ensuring good skin contact, reducing artefact due to patient movement, and crucially, placing the electrodes in the correct anatomical positions (Campbell et al, 2017). Given the importance and ubiquity of the 12-lead ECG in clinical practice, you might assume that high quality recording would be a core skill for nurses, as well as one that is high up the agenda of educators in both university and practice settings. Unfortunately, this does not appear to be the case.

In this edition of the *British Journal of Cardiac Nursing,* Pearce (2019) evaluates the causes and effects of electrode misplacement, concluding that the problem is widespread, and linked to numerous factors including inadequate education, lack of knowledge in practice, and increasing pressure of work in acute settings. This is a significant problem, as incorrect electrode placement has been linked to misdiagnosis, especially in suspected myocardial infarction (MI) (Jowett et al, 2005).

In many cases, misplacement is accidental, with poor placement of precordial electrodes an especially common problem (Rajaganeshan et al, 2008). Multiple factors appear to contribute to this phenomenon, including a poor understanding of correct positions, lack of expertise in identifying anatomical landmarks, and patient-related factors that may hamper correct placement, for example breast tissue.

Of equal concern is the trend towards torso placement of the limb leads. In Eindhoven's original work on the ECG, limb electrodes consisted of buckets of saline into which the two arms and left foot were placed (AlGhatrif and Lindsay, 2012). Subsequent research, and the guidelines arising from it, are based on limb electrodes placed on the limbs, and not on the torso. Torso placement of limb leads dates from the 1960s, when Mason and Likar (1966) described their use during exercise testing, moving the arm leads to just below the clavicles, and the leg leads to the abdomen. These positions were subsequently adopted for continuous cardiac monitoring, and their use has crept into 12-lead ECG recording, despite recommendations to the contrary (Campbell et al, 2017). They have many practical advantages; patient movement is less restricted, and artefact is reduced. Fewer clothes

need to be removed, increasing patient acceptability and speed of recording, which is useful in emergency settings.

The problem, however, lies in accuracy. Although Mason & Likar (1966) considered torso placed leads a direct equivalent to standard limb placement, subsequent research has demonstrated otherwise. In the best-known study, Jowett et al (2005) recorded 12-lead ECGs using standard and torso placed limb electrodes. They noted several changes in the torso placed recordings, including

- a rightward shift in the cardiac axis
- increased R-wave height in the inferior leads with loss of Q-wave depth
- decreased R-wave amplitude in leads I and aVL
- QS waves in V1 and V2 in some individuals

These changes resulted in the potential for misdiagnosis of acute MI in eight patients, and the disappearance of changes associated with inferior MI in five others. The possibility for unnecessary or missed treatment cannot be over-emphasised.

So, what is the answer?

Torso placement of limb leads is a common practice, and offers convenience, speed and reduced artefact. Unfortunately, it also results in subtle changes in axis and QRS morphology that may alter diagnosis, a fact that seems poorly understood in practice. Several studies have looked at alternative solutions, most notably Khan (2015) who studied the use of modified limb electrode placement using the mid-arm instead of the wrists, and the lower abdomen (three inches below the level of the umbilicus) instead of the feet.

In a study of over a thousand patients, Khan (2015) found no difference between ECGs produced using standard and modified limb lead positions. He argues that the key factors in producing this result were the placement of arm electrodes on the arms, not the chest, and leg electrodes placed low down on the abdomen. These are different from standard Mason-Likar positions, and may offer the best of both worlds; the low artefact and convenience of more centrally placed electrodes, with the accuracy of standard positioning.

Promising as this study is, there remains a compelling reason for caution in adopting its findings, and that is education. As Pearce (2019) points out, we have ample evidence that nurses and other health care professionals have a poor understanding of currently accepted lead positions, which includes limb leads placed on the ankles and wrists (Campbell et al, 2017). Adding an alternative system has the potential to cause confusion, unless an effective programme of education is implemented. This is undoubtedly needed, if only to educate nurses on current recommendations and the hazards of using Mason-Likar electrode positions. How such a programme of education would be implemented, and whether it is feasible in the current climate of financial restraint and under-staffing, are unanswered questions.

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