Value of Electrocardiographic Leads MCL₁, MCL₆ and Other Selected Leads in the Diagnosis of Wide QRS Complex Tachycardia

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To compare the modified precordial leads MCL₁ and MCL₆ with the conventional precordial leads V₁ and V₆, and assess the diagnostic accuracy of selected leads for continuous bedside electrocardiographic (ECG) monitoring, 121 wide QRS complex tachycardias were recorded from 92 patients during cardiac electrophysiologic study. As ascertained from intracardiac recordings, 86 tachycardias were ventricular and 35 were supraventricular with aberrant conduction. Early or late peaking of the predominant QRS deflection in lead MCL₁ or V₁ proved valuable in diagnosing wide complex tachycardia. An interval of ≥50 ms from the onset of the QRS complex to the predominant peak (or nadir) indicated supraventricular tachycardia; an interval of ≥70 ms indicated ventricular tachycardia. The QRS complexes in leads MCL₁ and MCL₆ were comparable to those in leads V₁ and V₆ during sinus rhythm.

Significant discrepancies in QRS configuration occurred between the modified and conventional precordial leads during ventricular tachycardia, especially between leads MCL₁ and V₁; however, these differences did not affect diagnostic accuracy. A single MCL₁, V₁, MCL₆ or V₆ lead was equally valuable in the diagnosis of wide complex tachycardia and far superior to a single lead II. A combination of leads (MCL₁ + MCL₆, V₁ + V₆, V₁ + I + AVF) or (V₁ + V₆ + I + AVF) was superior to a single lead or the routinely monitored lead V₁ + II combination.

Methods

Sample and setting. We prospectively analyzed 121 wide (>120 ms) QRS complex tachycardias recorded from 92 adults undergoing cardiac electrophysiologic study at the University of California-San Francisco. Informed consent was obtained as approved by the institution’s Committee on Human Research. In all patients, the site of origin of the tachycardia was verified by intracardiac recordings. Only
monomorphic tachycardias lasting at least 6 beats at a rate >100 beats/min were selected for analysis. Excessively rapid ventricular tachycardias ≥300 beats/min were excluded from analysis. Supraventricular tachycardias induced in patients who had bundle branch block at baseline study were excluded because the QRS complex during tachycardia exhibited the same bundle branch block configuration. In addition, patients with antidromic tachycardia were excluded. More than one tachycardia in the same patient was used in the analysis if the patient developed 1) both supraventricular and ventricular tachycardia, 2) supraventricular tachycardia with both right and left bundle branch block-type aberration, or 3) a second ventricular tachycardia with a clearly different QRS configuration. Ventricular tachycardias were defined as morphologically distinct if they exhibited different bundle branch block patterns or a markedly different (>60$^\circ$) frontal plane QRS axis.

**Instruments, procedure and analysis.** A conventional 12-lead ECG was recorded with a Marquette instrument that allowed for storage of the tachycardia recordings on a computer disk and retrieval in rhythm strip format. Modified leads MCL$_4$ and MCL$_6$, conventional leads V$_1$, and V$_6$, a high right atrial electrogram and three low right atrial septal electrograms (including the His bundle electrogram) were recorded continuously throughout the study with an Electronics for Medicine multichannel monitor and stored on a Hewlett-Packard eight-channel reel to reel tape recorder. Because the same electrode position was required for more than one lead (for example, both leads MCL$_1$ and V$_1$ required an electrode in the fourth intercostal space to the right of the sternum), electrode wires were soldered together so that the same skin electrode could be connected to more than one lead cable.

Leads MCL$_4$ and MCL$_6$ were compared with leads V$_1$ and V$_6$ in two ways. First, two independent observers rated the QRS complexes as identical, similar or clearly different during baseline sinus rhythm and during wide complex tachycardia. QRS complexes were judged to be identical when the complex from the two leads being compared contained identical component waves of equal or nearly equal width and height. They were rated as clearly different when they were obviously dissimilar (for example, the complex was primarily positive in one lead but primarily negative in the comparable lead). The complexes were rated as similar when the QRS complex in the two leads exhibited the same predominant polarity but contained minor variations in the component waves. Second, the MCL leads were compared with the V leads in terms of the well established QRS patterns suggestive of supraventricular tachycardia with aberrant conduction or ventricular tachycardia (1–5). Each of these QRS patterns was compared with the reference standard of intracardiac diagnosis of supraventricular or ventricular tachycardia with use of a one-tailed Fisher exact test to determine statistical significance. A QRS pattern was considered a valuable criterion if it was statistically associated with a diagnosis of supraventricular or ventricular tachycardia with a p value of <0.05.

To determine which leads were most valuable in diagnosing wide complex tachycardia, a diagnosis of supraventricular, ventricular or indeterminate tachycardia was made from rhythm strips and compared with the diagnosis ascertained during cardiac electrophysiologic study. The investigators did not know the true diagnosis and did not have access to clinical information such as the patient's medical history, age or physical findings. The single-lead or multiple-lead combination that allowed for the greatest diagnostic accuracy was deemed most valuable. Diagnostic accuracy was defined as the number of true detections of supraventricular plus ventricular tachycardia divided by the total number of wide complex tachycardias evaluated. A test for the difference between correlated proportions (McNemar test) was used to determine whether the observed differences in diagnostic accuracies between various leads and lead sets were statistically significant.

Leads evaluated were the single leads routinely used in clinical practice for continuous bedside monitoring and multiple-lead sets hypothesized to be of value. Single leads included MCL$_1$, V$_1$, MCL$_4$, V$_6$ and II. Dual leads evaluated included MCL$_1$ and MCL$_6$, V$_1$ and V$_6$, and V$_1$ and II. Multiple lead combinations evaluated included lead V$_1$ or V$_6$, or both, and I or aVF, or both.

**Criteria used to make the diagnosis of ventricular or supraventricular tachycardia.** Criteria for ventricular tachycardia were the presence of 1) atrioventricular (AV) dissociation (that is, presence of dissociated P waves, fusion or ventricular capture beats), 2) a QRS width >160 ms, 3) an axis in the upper left quadrant (that is, −90$^\circ$ to ≥180$^\circ$), 4) an axis in the upper right quadrant in tachycardias with a right bundle branch block pattern, 5) a concordant QRS pattern in leads V$_1$ and V$_6$ or MCL$_1$ and MCL$_4$, 6) QRS patterns suggestive of ventricular tachycardia in leads V$_1$, MCL$_1$, V$_6$ and MCL$_6$ (1–5) and, 7) late peaking (>70 ms) of the predominant QRS deflection in lead V$_6$ or MCL$_6$. Criteria used to make the diagnosis of supraventricular tachycardia with aberrant conduction were the presence of 1) QRS patterns suggestive of aberrancy in leads V$_1$, MCL$_1$, V$_6$ and MCL$_6$ (1–5), and 2) early peaking (≤50 ms) of the predominant QRS deflection in lead MCL$_6$ or V$_6$. Because nonstand-
ardized bedside ECG monitoring leads cannot provide for precise measurement of QRS axis in degrees, axis quadrants were determined by observing QRS polarity in leads I and aVF.

A diagnosis of ventricular tachycardia was made when one or more of the ventricular criteria were present in the single-lead or multiple-lead combination being evaluated. Likewise, a diagnosis of supraventricular tachycardia with aberrancy was made if one or more of the supraventricular criteria were present. When the tracing from the lead or leads in question contained both ventricular and supraventricular criteria, a diagnosis of indeterminate tachycardia was made unless AV dissociation was present, in which case the diagnosis was assumed to be ventricular tachycardia. A diagnosis of indeterminate tachycardia was also made when there were no criteria present in the particular lead or lead set with which to make a diagnosis.

To evaluate whether the new criteria improved the diagnosis of wide complex tachycardia, a measurement was made from QRS onset to the predominant peak (positive complexes) or nadir (negative complexes) at a paper speed of 50 mm/s in leads MCL₉ and Vₑ. Subsequently, a diagnosis was determined from these two leads with and without the new criteria factored into the analysis.

Results

Sample characteristics. Of the 121 wide QRS complex tachycardias, 35 were supraventricular with aberrant conduction; 86 were ventricular tachycardia. Supraventricular arrhythmia mechanisms included orthodromic tachycardia in 15 patients with Wolff-Parkinson-White syndrome, AV node reentry in 5, atrial tachycardia in 5 and sinus tachycardia in 1. In addition, nine cases of aberrant conduction with rapid atrial pacing were used in which the pacer stimulus was not apparent on the rhythm strip recordings. Ninety-six of the tachycardias were sustained, lasting 230 s; 16 of the tachycardias were nonsustained, lasting an average of 19 beats (range 7 to 42).

Comparison of MCL and V leads. A total of 424 comparisons were made by the two observers including: 1) 92 comparisons between leads MCL₁ and Vₑ during baseline rhythm, and 2) 120 comparisons between leads MCL₉ and Vₑ during wide complex tachycardia (1 of the 121 tachycardias was not recorded on leads MCL₉ and MCL₂). There was agreement between the two observers in rating the similarity between the modified and conventional precordial leads in >88% of the tracings. Most disagreements occurred because one observer rated an episode identical, but the other rated the episode similar. In these cases, both QRS complexes being compared had the same number, width and order of Q, R or S waves, but the height ratio of the component waves varied slightly. There were no instances in which one observer rated an episode identical in the two leads and the other rated the episode clearly different. All differences were readily resolved by consensus.

It was not uncommon for the QRS configuration to be identical in leads MCL₁ and Vₑ during baseline rhythm, but clearly different during ventricular tachycardia (Fig. 2). One striking difference in QRS configuration between leads MCL₁ and Vₑ was discovered serendipitously during ventricular overdrive pacing from the right ventricular outflow tract area. Although the QRS configuration in lead Vₑ always exhibited a primarily negative left bundle branch block pattern characteristic of right ventricular origin, in lead MCL₁ it not uncommonly exhibited a primarily positive right bundle branch block pattern. Although this finding was not systematically investigated from the beginning of the series, it was noted during right ventricular outflow tract electrical stimulation in 18 patients and was observed in the 1 patient whose spontaneous ventricular tachycardia was diagnosed as right ventricular outflow tract in origin (Fig. 3).

A summary of the QRS comparisons between leads MCL and V is shown in Table 1: 90% of patients had an identical or similar QRS configuration in leads MCL₁ and Vₑ during baseline rhythm. An even greater proportion (95.5%) had an identical or similar QRS configuration in leads MCL₉ and Vₑ. During aberrant supraventricular tachycardia, the QRS configuration was identical or similar in leads MCL₁ and Vₑ in
Figure 3. Pacing from the right ventricular outflow tract (A) and spontaneous nonsustained ventricular tachycardia (B) in a 26-year-old woman with right ventricular dysplasia. Pace-mapping of the right ventricle during electrophysiologic study revealed that the ventricular tachycardia originated from the right ventricular outflow tract. The QRS configuration is identical in leads MCL, and V, during sinus rhythm; however, it is clearly different during the ventricular rhythm. Although lead V, has a left bundle branch block pattern characteristic of right ventricular origin, lead MCL, has a right bundle branch block pattern characteristic of left ventricular origin. In contrast to the right precordial leads, the QRS configuration is nearly identical in leads MCL, and V, during both sinus and ventricular rhythms.

89% of the episodes and in leads MCL, and V, in 94% of the episodes. During ventricular tachycardia, however, the QRS configuration often clearly differed in the modified and conventional leads, especially in leads MCL, and V,. For example, 38% of the ventricular tachycardias had a clearly different QRS configuration in leads MCL, and V,. In fact, only 22% (26%) of the 85 ventricular tachycardias had an identical QRS configuration in leads MCL, and V,.

Figure 4. Presence of the well established morphologic criteria in lead MCL, compared with those in lead V, during tachycardias with a right bundle branch block pattern.

Morphologic criteria in lead MCL, compared with lead V,.

Findings from the present study supported previous studies (2,3,5) of morphologic criteria in lead V, with one exception: a monophasic R wave pattern was not statistically associated with ventricular tachycardia in either lead MCL, or lead V, (Fig. 4). During tachycardias with a right bundle branch block pattern, a taller left peak or biphasic QR or Rs pattern occurred only in patients with ventricular tachycardia (Fig. 4). An rSR or rsR pattern was suggestive of supraventricular tachycardia with aberrant conduction; however, such patterns were also occasionally seen during ventricular tachycardia in leads MCL, and V, (7% and 8% of ventricular tachycardias in leads MCL, and V, respectively).

The QRS patterns that were most discriminating in tachycardias with a left bundle branch block contour in leads MCL, and V, (Fig. 5) were those that exhibited the criteria described by Kindwall et al. (1) for diagnosing ventricular tachycardia (namely, a prolonged R wave, notched S downstroke or late nadir). In fact, none of the 35 aberrantly conducted supraventricular tachycardias had any one of these criteria in lead MCL, or V,. A delayed S nadir was the most sensitive of these three criteria, accompanying all but one case of widened R or notched S wave. As expected, absence of the criteria of Kindwall et al. (1) in a single MCL, or V, lead was less useful in detecting aberrant conduction because the prolonged R wave, S notch or late nadir was sometimes evident only in lead V,.

Table 1. Comparison of Modified and Conventional Precordial Leads in 120 Episodes of Wide Complex Tachycardia in 92 Patients

<table>
<thead>
<tr>
<th>Rhythm</th>
<th>No.</th>
<th>Leads</th>
<th>Identical (%)</th>
<th>Similar (%)</th>
<th>Different (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>92</td>
<td>MCL, vs. V,</td>
<td>67</td>
<td>23</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MCL, vs. V,</td>
<td>66</td>
<td>29.5</td>
<td>6</td>
</tr>
<tr>
<td>Aberrant</td>
<td>35</td>
<td>MCL, vs. V,</td>
<td>63</td>
<td>26</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MCL, vs. V,</td>
<td>68</td>
<td>26</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MCL, vs. V,</td>
<td>63</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>Ventricular tachycardia</td>
<td>85*</td>
<td>MCL, vs. V,</td>
<td>26</td>
<td>36</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MCL, vs. V,</td>
<td>63</td>
<td>19</td>
<td>18</td>
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*One of the 121 tachycardias was not recorded on leads MCL, and MCL.
Morphologic criteria in lead MCL₆ compared with lead V₆ (Fig. 6). In tachycardias with a right bundle branch block pattern, a biphasic Rs pattern with an R/S ratio < 1 in lead V₆ was suggestive of ventricular tachycardia. In lead MCL₆, however, this Rs pattern was not statistically associated with ventricular tachycardia. A triphasic qRs pattern with an R:S ratio > 1 indicated supraventricular tachycardia with aberrant conduction in both leads. In tachycardias of either right or left bundle branch block contour, a QS or qR pattern in leads MCL₆ and V₆ occurred only during ventricular tachycardia.

A majority (77%) of the tachycardias produced classic QRS configurations in leads MCL₆ and V₆ that were useful in establishing a diagnosis. In contrast, only 47% of the tachycardias produced diagnostic QRS patterns in leads MCL₆ and V₆. For example, the QRS configuration in lead MCL₆ or V₆ often had a monophasic R or biphasic Rs pattern, which was as likely to indicate supraventricular tachycardia with aberrancy as ventricular tachycardia unless the monophasic R wave was associated with a concordant pattern. Thus, a single MCL₆ or V₆ lead was more likely than a single MCL₆ or V₆ lead to record morphologic criteria for making a diagnosis.

With the exception of the Rs pattern in lead MCL₆, all other QRS configurations that were statistically significant criteria in the conventional V leads were also valuable in the MCL leads. Thus, despite occasional QRS differences during tachycardia between a V lead and its MCL lead counterpart, the dissimilar patterns indicated the same diagnosis.

The “supraventricular” criterion (≤ 50 ms) was highly specific for aberrantly conducted supraventricular tachycardia (93% and 92% in leads MCL₆ and V₆, respectively), as was the “ventricular” criterion (≥ 70 ms) (specificity 99% and 94% in leads MCL₆ and V₆, respectively). Moreover, these new criteria were observed often enough during wide QRS complex tachycardia to be of value in making the diagnosis. For example, the sensitivity of the supraventricular criterion was 71% and 77% in leads MCL₆ and V₆, respectively; the sensitivity of the ventricular criterion was 71% and 72% in leads MCL₆ and V₆, respectively.

The “selected leads.” As indicated in Figure 9, 74% of the tachycardias were identified correctly from a single MCL₆ lead; 79%, 78% and 71% were identified correctly from a single V₆, MCL₆, and V₆ lead, respectively. These differences were not statistically significant. The new criteria (early and late peaking of the predominant deflection) greatly improved the diagnostic accuracy of leads MCL₆ and V₆. For example, the diagnostic accuracy of leads MCL₆ and V₆ without the new criteria factored into the analysis was just 60%. Only 34% of the tachycardias were detected by using a single lead II. The low diagnostic accuracy of lead II resulted from the relatively long duration of the tachycardia during which the ventricular depolarization wave front was still in progress.
from the inability to identify right or left bundle branch block patterns, an essential step in diagnosing supraventricular tachycardia with aberrancy.

An interesting finding was that 90% of the tachycardias were identified correctly by using the combination of precordial lead MCL1 plus MCL6 or lead V1 plus V6, which was superior to making the diagnosis from a single precordial lead or the routinely used combination of lead V1 plus lead II. Monitoring with lead V1 plus II was not superior to monitoring with a single MCL1, V1, MCL6 or V6 lead in diagnosing wide complex tachycardia. The results of the three-lead combination of V1, I and aVF (diagnostic accuracy 88%) and the four-lead combination of V1, V6, I and aVF (diagnostic accuracy 93%) were not statistically different from those of the dual precordial leads.

Discussion

This is the first study to validate use of the modified precordial leads MCL1 and MCL6 for diagnosing wide QRS complex tachycardia. The vast majority of both normal and wide QRS complexes have identical (or nearly identical) patterns in leads MCL1 and V6. Although the QRS configuration clearly differs between leads MCL1 and V1 in about one third of wide complex tachycardias, no difference in diagnostic accuracy results.

Monitoring with lead MCL1 versus V1. In contrast to V1 recordings, rhythms originating from the right ventricular outflow tract do not always have a left bundle branch block pattern in lead MCL1. We found that a monophasic R wave or taller left peak pattern in lead MCL1 was not uncommon during pacing from this region. In addition, the one ventricular tachycardia in our series that proved to be of right ventricular outflow tract origin demonstrated a monophasic R wave pattern in lead MCL1 but had the characteristic left bundle branch block pattern of right ventricular origin in lead V1. Such an uncharacteristic pattern in lead MCL1 is not surprising because the negative electrode of lead MCL1 is placed at the left shoulder. Thus, right ventricular outflow tract rhythms, which spread inferiorly (as well as left and posteriorly), may result in predominantly positive QRS complexes in this bipolar lead.

This observation has important clinical ramifications. For example, Marriott and Fogg (8) suggest that a major diagnostic advantage of monitoring patients with lead MCL1 is the ability to recognize the ventricles being paced with a temporary transvenous pacemaker. These authors explain that a change in the pacing pattern from right ventricular (a left bundle branch block pattern) to left ventricular (a right bundle branch block pattern) in lead MCL1 may indicate an otherwise silent perforation of the right ventricular wall or septum (with stimulation of the left ventricle) by the catheter tip. Such a perforation in a patient receiving thrombolytic or anticoagulant therapy necessitates immediate removal of the thrombus.
pacemaker catheter to avoid cardiac tamponade. The current study indicates that an alternative explanation for the change in pacing pattern from negative to positive complexes in lead MCL is migration of the pacing catheter from the right ventricular apex to the right ventricular outflow tract area.

Our findings support previous studies (1-3) of morphologic criteria with two exceptions: 1) a monophasic R wave pattern in lead MCL or V1 was not statistically associated with ventricular tachycardia, and 2) a biphasic RS complex during tachycardia with a right bundle branch block pattern was not indicative of ventricular tachycardia in lead MCL. The QRS patterns described by Kindwall et al. (1) for diagnosing ventricular tachycardia from leads V1 and V2 are valuable in making the diagnosis from a single V1 or MCL lead. However, use of a single V1 or MCL lead cannot in itself exclude ventricular tachycardia because the absence of a prolonged R wave, S notch or late nadir in lead V1 does not guarantee that such criteria are not present in lead V2.

Indeed, in the present study, the R wave was occasionally isoelectric in lead V1 or MCL, resulting in a complex that looked like supraventricular tachycardia with left bundle branch block aberration with the tell-tale prolonged R wave clearly visible in lead V2.

Criteria for distinguishing ventricular tachycardia from wide complex supraventricular tachycardia. Observation of early or late peaking of the predominant QRS deflection in leads MCL and V6 is valuable for distinguishing aberrantly conducted supraventricular tachycardia from ventricular tachycardia. Early peaking of ≤50 ms suggests supraventricular tachycardia; late peaking of ≥70 ms suggests ventricular tachycardia. This measurement is not difficult to make because the predominant peak and nadir are readily identifiable points. In theory, the criteria are logical for several reasons. Initial activation of the ventricles from an aberrantly conducted supraventricular impulse proceeds rapidly by means of the His-Purkinje conduction system to produce an initial sharp rapid deflection. Additionally, a majority of aberrantly conducted tachycardias exhibit a right bundle branch block contour. Activation of the left ventricle occurs in a more or less normal fashion by means of the intact left bundle branch to produce a normal R wave in lead MCL or V6, reflective of left ventricular free wall activation. Our findings indicate that the measurement from the onset of the QRS complex to the peak of this R wave is likely to be ≤50 ms during supraventricular tachycardia with aberrant conduction.

Limitations of the new criteria. A potential limitation of these new criteria is that aberrantly conducted supraventricular tachycardia may be misdiagnosed as ventricular tachycardia when, in the presence of diffuse myocardial disease or left ventricular hypertrophy, it exhibits a more slurred initial QRS deflection. However, this was not the case in the five patients with supraventricular tachycardia with left ventricular hypertrophy or intraventricular conduction delay in the present study. Likewise, the rare ventricular tachycardia that uses the conduction system (for example, fascicular or bundle branch reentrant mechanisms) may be misdiagnosed as supraventricular tachycardia because it exhibits an initial rapid QRS deflection, but this limitation extends to all previously proposed morphologic criteria.

If observation of the QRS configuration is limited to the previously proposed criteria, <50% of the tachycardias exhibit patterns useful in making a diagnosis from lead V6 or MCL. If, however, observation of the QRS configuration in these leads includes the new criteria, the vast majority of tachycardias exhibit diagnostic patterns. Thus, a single MCL or V6 lead becomes as valuable as a single MCL or V1 lead for continuous bedside ECG monitoring. This information is important because MCL or V1 leads are not always a practical choice for monitoring patients in critical care units. For example, a sternotomy incision in a patient recovering from cardiac surgery may preclude placement of an electrode near the sternum. Moreover, a patient with chronic obstructive pulmonary disease and accompanying increased anteroposterior chest dimension typically has a
low signal to noise ratio in lead MCL4 or V1 that may obfuscate proper diagnosis.

Advantage of combined lead sets. The present study demonstrates an advantage to monitoring with dual leads (V1 plus V4) or quadruple leads (V1, V6, I, and aVF). Such a four-lead combination makes it possible to record all the published criteria for distinguishing supraventricular tachycardia with aberrancy from ventricular tachycardia; namely, QRS axis, width, configuration in leads V1 and V6, including a concordant pattern, and the new criteria in lead V6 described here. Unfortunately, neither of these dual-lead or quadruple-lead combinations is available in clinical practice because current bedside ECG monitoring systems provide for recording only one V lead.

Clinical recommendations. Recommendations that can be made from the present study and incorporated into practice with currently available monitoring systems include the following. For single-channel bipolar monitors, an MCL1 or MCL6 lead has the highest diagnostic accuracy for wide QRS complex tachycardia. Lead MCL6 is as accurate as lead MCL1 only if the new criteria reported here (that is, early and late peaking of the predominant QRS deflection) are used to make the diagnosis. For dual-channel monitors, a combination of lead MCL1 plus lead MCL6 is superior to the routinely used combination of lead V1 plus lead II. However, such a lead placement has disadvantages. For example, it requires placing electrodes designated for the limbs on the chest, which may cause confusion (Fig. 10). In addition, it means that one cannot “scroll through” leads I, II, III, aVR, aVL, and aVF as indicated on the bedside monitor because the limb electrodes are no longer in their proper position. Thus, the lead identified on the monitor is not the tracing displayed on the oscilloscope. If a third ECG channel is available, the three-lead combination of V1, I, and aVF is comparable to lead MCL1 plus MCL4 without the need to displace electrodes from their designated locations.

In a recent random sample survey (6), 74% of critical care nurses using single-channel monitors indicated they monitored patients with lead II. Lead II plus either lead V1 or MCL1 were the leads of choice by the vast majority (87%) using dual-channel monitors. Monitoring manufacturers often recommend lead II for optimal monitoring, especially for use with arrhythmia computers. This recommendation, made by engineers whose goal is to provide a clean signal for analysis, is based on the fact that in most patients who have a normal frontal plane axis, the QRS complex in lead II has the greatest amplitude and thus the greatest signal to noise ratio. Although lead II often has a good quality, high amplitude signal, it is not helpful in making the diagnosis of bundle branch block, which is mandatory for diagnosing aberrant ventricular conduction.

It would be advantageous to have rhythm strip recorders with the capability of recording tracings at paper speeds other than the traditional 25 mm/s. For example, the criteria of Kindwall et al. (1) and the new criteria presented in the current study require accurate measurement of short intervals such as 30, 50, 60, and 70 ms. Rhythm strip recorders that can record tracings at faster paper speeds (for example, 100 mm/s) would make it possible to measure such short intervals with better precision. Moreover, because most bedside monitor signals are digitized, it should be feasible for monitoring systems to determine accurately various QRS intervals and widths by real-time computer analysis. Incorporation of such measurements along with the diagnostic QRS patterns into the arrhythmia computer algorithm would increase the accuracy of computer diagnoses of arrhythmias.

As the start of the 4th decade of coronary care approaches, there are still no specific guidelines on which or how many leads to monitor. In addition, there are no universally accepted standardized electrode placements for obtaining various leads. For example, some critical care textbooks indicate proper placement of the lead II positive electrode is on the left precordium, whereas others specify the lower left abdomen (6). Patients are monitored with a variety of leads within the same hospital and in different hospitals. Although a plethora of ECG rhythm strips are included in the patient’s permanent hospital record, there is little if any documentation as to which lead is recorded. For example, if a patient has documentation by a conventional 12-lead ECG of recurrent ventricular tachycardia that has precipitated an aborted sudden death, it is often impossible to tell whether the episodes of nonsustained ventricular...
tachycardia recorded from the bedside monitor represent the same malignant focus because lead placement has not been documented or standardized. A major reason for the paucity of specific guidelines to advise industry and standardize practice has been the lack of research on which to base these standards.

Conclusions

Our data can be summarized as follows. First, QRS complexes in leads MCL₃ and MCL₄ are comparable to those in leads V₁ and V₆ during sinus rhythm. Second, significant discrepancies in QRS configuration occur between the modified and conventional precordial leads during ventricular tachycardia, especially between leads MCL₃ and V₁; however, these differences do not affect diagnostic accuracy. Third, the observation of early or late peaking of the wide QRS complex in leads MCL₄ and V₆ is useful in distinguishing supraventricular from ventricular tachycardia. Diagnostic accuracy of a single MCL₁, V₁, MCL₆ or V₆ lead is comparable and far superior to that of a single lead II. Finally, combinations of leads (MCL₁ plus MCL₃), (V₁ plus V₆), (V₁ plus I plus aVF) or (V₁ plus V₆ plus I plus aVF) are superior to a single lead or to routine monitoring of a single lead II.

References

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