sensitive bipolar lead is between R_C and V_5. In addition to the CC_5 lead, Knight *et al.*[3] used a modified CM_5 lead where the positive electrode was at V_5 and the negative electrode was placed in the right supraclavicular fossa as close to the manubrium as possible. During acute anterior myocardial infarction[4] as well as during coronary angioplasty leading to anterior hypokinesia,[5] ST elevation in lead V_2 is more common than ST deviation in any other lead.

These lead systems can be readily implemented in the operating room with existing equipment. If a three-lead wire ECG cable is used, the right arm electrode may be placed at R_C, the left arm electrode at V_5, the right leg electrode at its customary location, and lead I monitored. If a five-lead wire cable is used, the right arm electrode may be placed at RV_5, which is analogous to the V_5 position on the right side, the left arm electrode at R_C, the left leg electrode at V_5, and the right leg electrode at the customary position. The chest electrode may be placed at V'_4 or V_4 or V_2. In this configuration, lead III becomes the most sensitive bipolar lead R_CV_5 and may be monitored along with the chest lead. Lead II will become the bipolar lead CC_5. The reference voltage for the unipolar chest lead acquired this way will be slightly different from that acquired with standard limb lead placement.

This lead placement will maximize the detection of ST deviation but, like any nonstandard lead placement, will obscure the interpretation of conduction, axis, and other changes such as T-wave inversions. This will also preclude any comparison of the intraoperative ECG with pre- and postoperative 12-lead ECG.

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In Reply:—We wish to thank Jain *et al.* for their complimentary remarks regarding our recent study.[1] The work of Kubota *et al.* is one of several studies utilizing multiple precordial leads or body surface potentials to investigate the surface projection of the ECG ischemic response.[2,3] Although such systems can increase the sensitivity of the ECG, these studies all emphasize the clinical value of the standard 12-lead ECG, particularly the lateral precordial leads.

The lead system Jain *et al.* have proposed would allow simultaneous monitoring of two bipolar V_5 leads. These leads reflect the: 1) similar (and often interchanged) CS_5 or CM_5 leads: negative electrode ("left arm" cable) at either the right midclavicular line (CS) or on the upper manubrium (CM), accessed *via* monitor lead III; and 2) the CC_5 lead: negative electrode ("right arm" cable) on the right-sided V_5 position accessed *via* monitor lead II. In both instances, the positive electrode ("left leg" cable) is placed on the V_5 precordial position. The precordial lead cable is now available for placement at other positions that may enhance sensitivity (*i.e.*, V_4, V_2, or lower interspace precordial positions). However, this precordial lead is really a "pseudo-Wilsons" central terminal lead as a result of the geometric rearrangement of Einthoven triangle. The "true" central terminal of Wilson is formed by joining the right arm, left arm, and left leg negative electrodes through equal resistances, resulting in a terminal of approximately zero potential.[4] Theoretically, this central terminal is located at the electrical center of the heart or the center of the equilateral Einthoven triangle. It is from this center that the vectors of each of the augmented unipolar limb leads (in the frontal plane) or the "standard" precordial leads (in the horizontal plane) originate. As such, this center defines the characteristics of these leads (amplitude and morphology of the P-QRS-T complex). Indeed, the simple modification of the 12-lead ECG popularized by Mason and Likar for treadmill testing (torso-mounting of the limb lead electrodes) can cause significant differences when compared to one obtained using wrist and ankle mounting of the limb electrodes.[5,6]

The "non-standard" lead system Jain and associates have proposed raises several clinically important concerns. Firstly, should bipolar V_5 leads be used preferentially over the "true" unipolar precordial leads? Historically, bipolar precordial leads were used earlier than unipolar leads for treadmill testing primarily due to simplicity of application and stability of the signal during exercise. Only after Mason and Likar reported on torso-mounted limb leads and computerized signal processing became available did multiple unipolar precordial leads become popular. Bipolar V_5 leads vary widely in the site of attachment of the negative lead.[7] Thus, each lead has a different axis that may alter the amplitude of the QRS components and the morphology of the ST

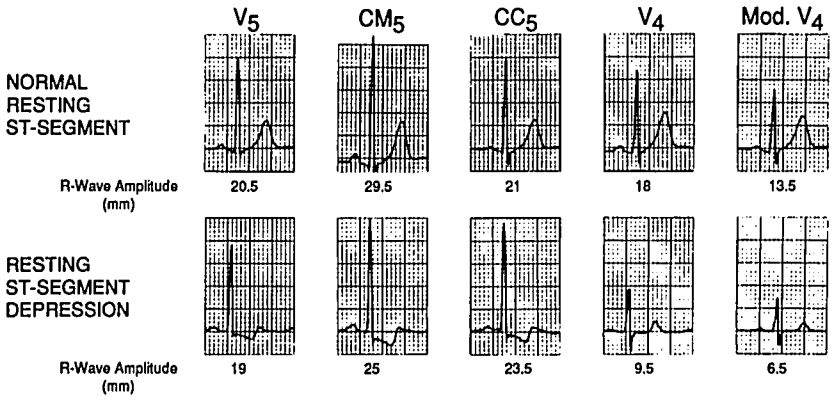

FIG. 1. Unipolar, bipolar, and modified precordial leads from a normal male and a patient with resting ST segment depression are shown. Tracings were obtained using a MAC II electrocardiograph (0.1 mv/mm) (Marquette Electronics, Milwaukee, WI). Modified Mason-Likar (torso-mounted leads) were used to obtain the unipolar V_4 and V_5 leads. A "modified" V_4 was obtained using the lead positions suggested by Jain and associates. Lead positions for bipolar CM_5 and CC_5 are described in text. Compared with the true unipolar equivalents, the R waves of the bipolar V_5 are larger and those of the modified V_4 are smaller. The greater R wave amplitude of CM_5 in the patient with resting ST segment depression is associated with a greater degree of ST depression.

segment.[8] Leads CM_5 and CC_5 have been the most extensively studied and have shown good sensitivity in detecting exercise induced ischemia when compared with 12 lead systems.[8-11]

Usually, the bipolar V_5 leads show greater R wave amplitude than standard precordial leads.[7] This may result in "amplification" of the ST segment response (fig. 1). Hollenberg and coworkers have shown that normalization of the degree of ST segment depression to the height of the R wave increases the sensitivity and specificity of treadmill exercise testing.[12] Although the significance of this finding in other settings (intraoperative, during ambulatory ST segment monitoring, etc.) remains to be established, it may be an important factor to consider when deciding on choice of lead systems.

Barazal and Norfleet comparing the bipolar V_5 lead CB_5 (negative electrode over the right scapula) to unipolar V_5 during intraoperative monitoring found all components of the QRS-ST complex to be 20% greater and the P wave amplitude 90% greater in CB_5.[13] However, despite the potential advantages of enhanced ischemia and atrial dysrhythmia detection, this lead is rarely used. In a recent report, Griffin and Kaplan compared a "modified" unipolar V_5 (using a "pseudo" central terminal arrangement) to CS_5 and CB_5 in three patients with ischemic changes during noncardiac surgery and found greater ST depression in the bipolar leads.[14] Thus, based on the accumulated studies from exercise testing, ambulatory monitoring and a limited number of perioperative studies, bipolar precordial leads appear to have similar, if not greater, sensitivity than their unipolar equivalents. However, further study is needed in the perioperative setting where anesthetic effects and different hemodynamic responses to "stress" may occur.

Secondly, the use of the "pseudo" central terminal lead has no precedence in the literature and should be used with caution. We are unaware of any studies comparing such a lead with its true precordial equivalent. Examples of this lead are shown in figure 1. Although there are no gross differences in morphology, there are differences in R wave amplitude. Clearly further study is indicated in a large, well-defined population if such a lead is to be used clinically.

Thirdly, and perhaps most importantly, this lead system would preclude the use of all other leads besides the bipolar V_5s and the exploring precordial lead. Thus, visualization of atrial activity and localization of ischemic responses (especially with ST segment elevation in other leads) might well be impaired.[15] For example, during CABG surgery, failure to scan the lateral or inferior leads might impair diagnosis of acute graft occlusion or spasm.[16]

In summary, we support the use of a CM_5, CS_5, or CC_5 lead (or combinations thereof) when the clinician is restricted to using a three-lead monitor. In patients in whom monitoring of atrial activity is a high priority, CB_5 is a useful, although less practical, alternative. An esophageal electrode as well may allow detection of posterior ischemia and better definition of supraventricular electrical activity.[17] For seven-lead monitoring systems, for the reasons outlined above, we do not recommend the modification that Jain and his associates have proposed. Given the increasing sophistication of operating room and intensive care unit ECG monitors (signal processing, digital trending, multiple lead disclosure, etc.), we can hardly recommend substitution of bipolar or "non-standard" lead configurations to the exclusion of their unipolar equivalents, especially when these leads may not be comparable to the patient's 12-lead ECG.

Indeed, we endorse recent guidelines drafted by the American Heart Association aimed at promoting uniformity in all aspects of intensive care ECG monitoring be they related to choice of lead systems, electrical performance of instrumentation, or education of nursing and medical personnel.[18] Hopefully, inclusion of additional amplifiers into future generations of ECG monitors will allow simultaneous monitoring of multiple unipolar precordial leads. In patients with known or suspected CAD, we recommend use of "torso-mounted" limb leads together with a unipolar V_5 lead. If it is known that a patient has developed significant ischemic changes limited to a precordial lead other than V_5, then monitoring that lead would seem to be indicated.

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Modified Rapid Sequence Induction. I.

To the Editor:—Cicala described an alternative method of administering vecuronium for rapid sequence inductions.[1] Having completed a study in which we administered vecuronium prior to the induction agent,[2] we feel a few points deserve comment.

The authors should be commended for using a succinylcholine control group in their study. A recent paper by Baumgarten has emphasized the importance of including this group in any study evaluating intubating conditions.[3] The fact that the study was not conducted in a blinded fashion, however, represents a serious flaw in the study's design. We disagree that the use of a large number of anesthesia personnel who were involved in less than ten cases eliminates investigator bias. Double blinded studies using succinylcholine can be accomplished by having the "intubator" not observe the patient until the time of intubation.

Furthermore, the authors' statement that this technique is an acceptable alternative in patients in whom succinylcholine is contraindicated is not supported by their results. Greater than 50% of the patients in the vecuronium group (24/50 grade 2, 2/50 grade 1) had "diaphragmatic movement" after intubation. We interpret this movement as "bucking." Clearly, this is not acceptable in patients with open eye injuries or increased intracranial pressure.

Finally, without a group of patients in whom vecuronium is given in a standard priming sequence, we do not know if the authors' variation truly represents an improvement over previously described priming techniques. Intubating conditions may have been just as good (or bad) using the standard priming principle.

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