This is especially true if one is not familiar with the purging method or when little help is available, *e.g.*, weekends or nights. Purging the machine during an MH crisis diverts one's attention away from managing the patient.

The circle system with a CO_2 absorber is the circuit of choice in MHS patients, be it a purged machine[2] or a dedicated clean machine. The purge should take less than 10 min to perform. In facilities that do not have a dedicated clean machine, I suggest that the purging instructions and replacement tubing be kept on the MH treatment cart. Whether the system described by Donahue and Schulz is adequate to give an uneventful anesthetic is not the issue. It is just not the best that we have to offer.

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In Reply:—We appreciate the comments offered by Dr. Allen. Our system was designed for use in infants and children with indications of malignant hyperthermia susceptibility (MHS) (*i.e.*, an unexplained fever after a previous anesthetic, a questionable diagnosis of myotonia). These patients were coming to surgery for minor procedures (*i.e.*, inguinal herniorraphy, muscle biopsy, pressure equalization tubes). The system has worked well in these cases; however, as pointed out by Dr. Allen, none of these patients developed a malignant hyperthermia (MH) crisis.

The Bird Products Corp., Palm Springs, California, manufactures two nitrous oxide/oxygen (N_2O/O_2) blenders. A low flow model (No. 2903) that allows fresh gas flows (FGF) of 2–18 liters per minute (LPM) and a high flow model (No. 2902) with FGF of 15–100 LPM. The low flow blender was chosen because of the size of the involved patient population. In children less than 25 kg, our system would provide the increased minute ventilation recommended during an MH crisis without rebreathing.[1,2] Use of their high flow blender in larger patients would eliminate the possibility of rebreathing in this group also.

We agree with Dr. Allen that, during an MH crisis, the breathing system must be able to deliver high flow oxygen. Many systems can do this. A high flow nonrebreathing system may be advantageous because it would eliminate the rebreathing of exhaled volatile agents as well as the heating of inspired gases by the exothermic reaction in the CO2 absorber.

The avoidance of triggering agents, close monitoring, and a high index of suspicion are crucial when dealing with MHS patients. Our system is simple, portable, and clearly uncontaminated and we believe it has merit in this patient population.

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Electrocardiographic Lead Systems

To the Editor:—In their excellent study, London *et al.*[1] found that for the intraoperative detection of ST segment deviation, among the 12 standard electrocardiographic (ECG) leads, lead V_5 and then V_4 are the most sensitive. We would like to add that Kubota *et al.*[2] and others made similar observations in supine patients after treadmill exercise, suggesting that other findings from exercise testing may also be applicable to the perioperative setting.

Kubota *et al.*[2] studied ST changes in 87 body surface leads in 61 patients. After exercise, ST depression was evident in V_5 lead in 87% of the patients. ST depression occurred only in leads other than V_4, V_5, and V_6 in 10% of the patients. The most sensitive leads were V_5, V_5', V_4', V_4, V_6', and V_6, respectively. Leads V_4', V_5', and V_6' are one interspace below V_4, V_5, and V_6, respectively.

Concomitant ST elevation was present in right upper chest leads in 74% of the patients. Of these, 87% had ST elevation at a location just below the right clavicle on the midclavicular line (R_C). Thus the most

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 $R_C V_5$ 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