

CORRESPONDENCE

Badner *et al.*¹ confirm that postoperative heart rate is strongly associated with postoperative MI (PMI). For reasons that are not clear, however, lower opioid use was more strongly associated with PMI than was blood pressure, history of angina and MI, and previous bypass surgery. Only height, weight, age, and nitrate use were predictive among the other patient characteristics that were investigated.

The use of multivariable statistical models could be helpful in further developing and interpreting risk profiles. For example, only heart rate measured on days 1 and 2 after surgery were associated with PMI. This does not imply, however, that elevated heart rate before or after these days is unimportant. If preoperative heart rates are also available, we could develop models that would evaluate the combined effects of heart rate before surgery and change in heart rate during time after surgery and of the absolute postoperative heart rate. In this way, we could determine the features of the time course of heart rate that most contribute to risk—an analysis that might be of interest in itself, but also useful for suggesting therapeutics to reduce risk (see Mangano *et al.*)³

If the data set and number of endpoints were larger, the development of risk profiles could make use of multivariable regression models to evaluate simultaneously the relative contributions of demographics, clinical characteristics, and medical history to risk of MI, death, or both (see Marshall *et al.*)⁴. But, even in a smaller data set, we could evaluate the combined effect of a few characteristics in this way. Such analysis might start by investigating the relationships among the predictors of PMI and death, by determining whether patients with higher heart rates received less opioid. Then, multivariate models could help in identifying which characteristics independently predict adverse outcomes. For example, if higher heart rate is associated with less opioid use, then predictive models that include both variables would help to determine whether the opioid use reduced death because of its effect on heart rate or independently of that effect.

Such models could also help in the development of a definition or definitions for MI that best predict future cardiac disease outcomes. Although the authors found no difference in cardiac outcome in the four definitions of MI presented, more sophisticated statistical methods might help to further define MI according to the prediction of subse-

quent events. Such definitions might help in risk stratification. Such analyses must be based on all surgical information, not just MI-related deaths, because deaths from competing risks may result in biased analyses unless properly incorporated into statistical models. The reason is that deaths from causes indirectly related to MI eliminate the risk of MI for the patient.

Development and validation of risk profiles for MI and other adverse surgical outcomes may necessitate larger databases for adequate precision. The valuable data set of Badner *et al.*¹ might be combined with other sources of information to ensure adequate power for these investigations.

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In Reply:—We thank Drs. Litwack and De Gruttola for their interest in our manuscript investigating postoperative myocardial infarction (PMI) after noncardiac surgery. As indicated, they would have preferred the use of multivariable statistical models in our data analysis. To answer their questions regarding change in heart rate and opioid use and the relative contributions of demographics, we performed a stepwise logistic regression using the variables listed in tables 2 and 3 of our original manuscript and postoperative change in heart rate. The main results are shown in the table. One can see that age and nitrate usage again were significantly linked with PMI. Change in heart rate on postoperative day 4 was determined to be a risk factor for PMI. Interestingly, hypotension in the postanesthetic care unit was the most significant risk factor for PMI. The decreased narcotic requirements in

PMI patients again were not a significant risk factor. As indicated in our manuscript, we cannot determine whether the heart rate changes were the cause or the result of the PMI because of our lack of continuous heart rate recording. Similarly, postanesthetic care unit hypotension may have been an early clinical sign of the developing PMI and not a causative event because our enzyme assays were not performed before postanesthetic care unit arrival.

We cannot answer their question regarding the definition of MI and subsequent events because we did not, nor do we, have the ability to determine the occurrence of all non-MI deaths that occurred. Lastly, we would be happy to share our database, as suggested, to enable the development and validation of risk profiles for MI and other surgical outcomes with appropriate investigators.

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In Reply:—Drs. Litwak and DeGruttola appropriately advocate the use of more sophisticated statistical modeling techniques for developing and interpreting risk profiles in patients undergoing surgery. Clearly, surgical patients are not only older and more sick, but also have a broad array of acute and chronic diseases. Therefore, no universal paradigm can be created for perioperative care, and only through risk stratification can appropriate and cost-effective paradigms be tailored to individual patients. Therefore, our energy should be focused on developing greater sophistication in our approaches, as recommended by Drs. Litwak and DeGruttola.

Another issue addresses the characterization of the heart rate response and the association with adverse outcome. We now understand that elevations in heart rate occur commonly with emergence from anesthesia and throughout the first postoperative week, even when pain responses have been controlled. Such elevations in heart rate not only affect patients with fixed coronary artery stenosis, but also those with unstable plaque and endothelial dysfunction *vis a vis* plaque alteration by increased sheer stress. We also have appreciated that such alterations manifest not only acutely after surgery, but also during the weeks to months after hospital discharge. As suggested by Drs. Litwak and DeGruttola, more comprehensive characterization of the heart rate response may lead to greater insight into this pivotal association with

adverse outcome, thereby facilitating a more rational design of in-hospital and long-term therapeutic paradigms. Although the recent findings show that perioperative β blockade improves long-term survival are noteworthy, this approach is only the first step in the development of a comprehensive paradigm. We need to look no further than the experiences derived from clinical trials in ambulatory patients with cardiovascular disease. Only by intelligent stratification can the appropriate therapies be determined for an individual surgical patient, in whom excitotoxic and inflammatory responses are added to the inherent pathology of the chronic disease state.

Therefore, the questions raised by Drs. Litwak and DeGruttola clearly are important because they emphasize the complexity of the perioperative pathophysiologic derangements and the implications regarding postdischarge adverse outcome.

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Obstetric Anesthesia 1988-1996 in Northrhine/Germany: Results of the Perinatal Survey at the Chambers of Physicians

To the Editor:—Dr. Hawkins and colleagues¹ have to be congratulated on their task. To provide comparative information for Germany, we used the data contained in the Rhineland Perinatal Survey at the Chamber of Physicians of Northrhine/Germany (Rheinische Perinatal-Erhebung bei der Ärztekammer Nordrhein/RPE). Our goal was to evaluate the distribution of births among hospitals of different sizes and to define the use of regional and general anesthesia.²

Note that it is mandatory to report perinatal data to the Perinatal Survey at the Chamber of Physicians of Northrhine. The collected data

regarding number of births were compared with the data supplied by the State Office of Statistics. This verified the completeness of the data (99.3%).

The survey monitored 890,422 births between 1988 and 1996.

Of these, 654,308 were spontaneous deliveries. The number of all labor epidurals increased from 22,355 (24.3%) in 1988 to 24,095 (24.4%) in 1996.

In 1988, 15,038 patients underwent cesarean sections. In 1996, the number had risen to 19,767 patients, which constitutes 20.1% of all deliveries. This is an increase of 4,729 deliveries or 3.7%. The increase