same result in our most recent analysis. Whether these findings of mainly severe intraoperative hemodynamic disturbance may be risks for clinically important postoperative morbidity is not known. The thorough review of perioperative cardiac morbidity by Mangano[6] presented "preliminary findings" on dynamic predictors, and he concluded that "a casual relationship between hypotension and ischemia may exist; however, neither the degree nor the duration of hypotension necessary to precipitate ischemia has been determined." Also, in several studies, ischemic events have been reported in patients with decreases in intraoperative blood pressure of 20% or less.[7,8] For all of these reasons we are confident that the criteria used for these hemodynamic outcomes were appropriate for our study since we wished all episodes to be reported. Also, it was necessary to minimize as far as possible any observer bias as to their clinical importance.

We would like to extend the concluding statement by Pace by observing that our study could not demonstrate a difference among the anesthetic agents for mortality, myocardial infarction, and stroke because of insufficient sample size. We agree that the importance of differences in severe hemodynamic disturbance in the context of mortality or serious morbidity is not known. Clearly this should be investigated.

It should be remembered that most of our patients were healthy, and thus the statistical safety net of a large denominator may have obscured our ability to focus on those patients in most need of our expertise and vigilance. Despite this, we hope our study will stimulate questions, such as Burke and Pace ask as a basis for future study. We are most grateful for their interest and thoughtful comments.

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A Few Details Regarding Tonometric Measurement of Blood Pressure

To the Editor:—A long-time student of techniques of blood pressure measurement, I am disturbed by several aspects of the paper by Kemmotsu and colleagues on arterial tonometry.[1]

Why did the authors use a 22-G cannula for intraarterial pressure measurement? The norm in this country has been an 18-G cannula, although the emerging fashion is to use a 20-G. A cannula of still smaller bore may serve only to sanitize (by damping) the derived traces, perhaps contributing to the otherwise implausible damping coefficients of up to 0.5. By smoothing the direct arterial trace, one might then expect to have better concordance between direct and indirect systolic readings.

The authors' selection of citations would imply that "major problems such as infections and thromboembolic and traumatic complications" *commonly* follow intraarterial cannulation for pressure measurement. The literature, however, supports the view that arterial cannulation is a remarkably benign procedure insofar as major circulatory problems are considered,[3,4] and that infection is rare even in the critically ill, chronically cannulated patient.[5]

In their discussion, the authors aver that "the technique of arterial tonometry was invented in the early 1960's." Not so! Etienne Jules Marey demonstrated his "sphygmograph" at the court of Napoleon III; this sphygmograph was a portable device, applied to the wrist, that would record on a moving, smoked glass plate "the pulsebeats of an artery, not only with their frequency, regularity, and relative intensity, but also with the individual shape of each one."* The device was available from Charles Verdin, instrument maker in Paris, about 1890. A

comprehensive history of arterial tonometry appears in the opening chapter of a just-published text by Michael O'Rourke and colleagues.[6]

The Kemmotsu *et al.*[1] go on to disclose that the tonometric artifact is calibrated against an oscillometric blood pressure measurement system and that the oscillometric blood pressure module has been "certified by the Federal Drug Administration." There is no such thing as a "Federal Drug Administration." There *is* a Food and Drug Administration (FDA), which has authority only to determine whether a drug or device sold across state lines is safe and effective for the uses listed on the label of the product. Whether the FDA does or does not "approve" a drug or device is irrelevant to scientific medical practice (although such "approval" can be a highly charged political issue because of reimbursement considerations).

For evaluation of blood pressure–measuring devices, the FDA depends on the manufacturer to provide assurance that a particular blood pressure device has been tested (by the manufacturer) in accordance with a consensus standard drawn up by a committee of the Association for the Advancement of Medical Instrumentation.† The documentation filed with the FDA is available to the interested professional only through exercise of the Freedom of Information Act. An article in a respected scientific journal should not be based on distant and opaque bibliographic resources.

For their final indignity, the authors reveal that their calibration system "uses proprietary algorithms to determine systolic and diastolic pressures." This—"proprietary algorithm"—in a scientific journal? Surely you would not think of publishing in ANESTHESIOLOGY an article on the induction of anesthesia using a "proprietary" drug!

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* Exhibition and catalog on Etienne Jules Marey implemented by Medtronic France S.A., presented at the VIII European Congress of Cardiology, June, 1980. Catalog and reprint from Medical Heritage, 1986, kindly supplied by Albert W. Kuhfeld, Ph.D., the Bakken Library and Museum, Minneapolis, Minnesota.

† Personal communication: Don Dahms, Division of Cardiovascular, Respiratory, and Neurological Devices, Food and Drug Administration, November 7, 1991, and James Cheng, December 2, 1991.

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In Reply:—It is our routine practice to use a 22-G Teflon cannula for the radial artery to minimize vascular damage. We can usually obtain good pressure waveforms by 22-G cannulas in the radial artery, as one can see in figure 4 of our paper.[1] Presumably, Japanese people have smaller radial arteries than Americans. Use of an 18G cannula, almost never seen in Japan, would have resulted in a highly underdamped system, requiring use of an external damping device to avoid overestimation of the systolic blood pressure. The advantages of a small arterial cannula include the following: 1) it reduces the incidence of vascular complications; 2) by preventing occlusion of the artery, it helps to keep the point of wave reflection distal to the site of pressure monitoring; and 3) it tends to dampen the naturally underdamped catheter-extension tube system so that there is less "ringing" in the pressure wave, and systolic pressure is measured more accurately.[2]

Allen's test may be a fetish of defensive medicine and has no established predictive innocuousness of arterial cannulation. There are publications, as cited by Bruner, that decry the importance of this test, but our use of the test has no bearing on the scientific content of the paper and can scarcely have decreased patient safety. However, we still think it advisable, especially from a medicolegal standpoint, to avoid cannulating the radial artery if Allen's test is abnormal. We are aware that there is no guarantee of risk-free cannulation even if a normal Allen's test is obtained before cannulation.[5]

Although arterial cannulation seems to be a remarkably low-risk or benign procedure, major complications are not unknown. We should do our best to avoid complications associated with arterial cannulations even if an overall incidence of severe vascular compromise due to radial artery cannulation is only 0.01%. We agree that major complications are uncommon but remain convinced that a noninvasive procedure, if it can give the same information, would be preferred by most anesthesiologists. A recent report concluded that rates of arterial catheter-associated infections are low.[4] However, nosocominal infection with methicillin-resistant *Staphylococcus aurens* is now becoming a major problem not only in Japan but also in other countries. Safety considerations related to acquired immunodeficiency syndrome and hepatitis, which are becoming a serious problem in the perception of medical personnel, also favor use of noninvasive methods.

We see little value in disputing the inventorship of tonometry in this forum. Still, we would call Bruner's attention to United States Patent 3,219,035. This patent was granted in 1965 and indicates that the U.S. Patent Office was persuaded that tonometric blood pressure measurement was invented by Pressman, Newgard, and Eige sometime before the filing date, May 6, 1963. Perhaps Bruner's assertion that arterial tonometry was invented before 1890 arises from a disagreement about semantics, rather than history. Briefly, we define arterial tonometry as follows: 1) It uses an arterial rider that is smaller than the artery; 2) the artery is partially flattened, but not occluded; 3) the rider is supported rigidly so that it does not move significantly due to the arterial pulse; 4) the force exerted by the rider is measured, and this force is proportional to the arterial pressure; and 5) it measures the