

## CORRESPONDENCE

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**In Reply:**—We appreciate the interest of Drs. Aronson and Cook in our work and the opportunity to respond to their letter. One of our goals was to increase the level of awareness about the costs *versus* benefits of new medical technology. The response to our article, typified by Aronson and Cook's letter, indicate a modicum of success.

With respect to the benefits of TEE, we certainly agree that it can be an extremely useful clinical tool in many clinical situations. We also agree that it can enhance one's understanding of the cardiovascular physiology and clinical condition of a given patient. The use of TEE may improve outcome in some clinical settings, but not necessarily in all. Our study focused on the use of TEE in the pre-bypass period, primarily as a monitor of myocardial ischemia, in patients having CABG procedures. There appears to be little direct evidence for a clear clinical benefit of TEE as an ischemia monitor in this setting.\* However, regardless of its potential effects on outcome, one needs to understand the ramifications of its use.

We suggest that, in addition to the economic costs of TEE purchase and upkeep, there may be important non-economic costs associated with TEE use, or any other technology for that matter. The results of our objective research showed that the use of TEE by the subjects we studied was associated with: (1) a higher level of workload (as measured by subjective ratings and a procedural measure, workload density); and (2) a delay in their response to an additional simple stimulus, relative to their response when TEE was not in use. We inferred from this latter finding that the subject's vigilance to this stimulus was reduced, although we do discuss that, technically speaking, it may well have been their "spare capacity" that was reduced at this time rather than their "vigilance." These results should not be surprising, given the typical physical location of the TEE monitor (out of the field of view of the other anesthesia monitors), the device's complexity, and the high information content of the display.

The implication of these findings, as discussed in our original arti-

cle, is that the insertion and monitoring of TEE comes at a price—the price being a reduced ability to attend to other tasks or clinical events occurring at the same time. This is the first study to *measure* a degradation of attention associated with the use of TEE. Certainly, it is the clinician's responsibility to determine at any given time which activity will have the best payoff in terms of information yield *versus* attention/workload. However, one cannot ascertain the conditions in which TEE use will have a favorable cost-benefit profile without considering both sides of the equation.

We must correct one misunderstanding. In our study, the TEE probe and monitor remained in the operating room for the entire duration of every case studied.

We acknowledged in our article that the subjects we studied were relatively inexperienced TEE users, generally having attended several didactic lectures and received numerous one-on-one teaching sessions in the operating room over 6-8 weeks of cardiac anesthesia subspecialty training. However, many users in the private world have not had any more formal training than these senior residents. People who do not use TEE all the time may stay in a very prolonged phase of moderate skill, so the data from our study may not be too far removed from actual practice in many sites. Nevertheless, a follow-up study involving experienced TEE users could be illuminating.

Aronson and Cook make a number of theoretical suggestions about what the anesthesia provider "does" in his or her head. They may well be right in these suppositions, but their suggestions remain speculation and are not supported either by our data or by any other data of which we are aware. For example, they assert that TEE "provides information efficiently and precisely . . . increases the practitioner's knowledge . . . [and consequently] its use will decrease workload rather than increase it." Although this may be true for some clinicians with some patients, we are not convinced that it is a universal truism. Both of us have observed clinicians become so absorbed with the TEE that they fail to attend sufficiently well to other clinical tasks or to the patient's clinical status. We admit that we have sometimes been similarly absorbed when teaching residents about the TEE in the operating room despite our knowledge of the risks of degraded vigilance. Perhaps further studies are needed to ascertain the cognitive value of TEE *versus* other modalities and net the impact of TEE use on situation awareness in different settings. We would be most interested in any data that support Aronson and Cook's assertions.

\* Thys DM, Abel M, Bollen BA, Cahalan MK, Curling P, Dean RJ, Paulus D, Pearlman AS, Roizen MF, Smith H, Stewart WJ, Woolf SH: Perioperative transesophageal echocardiography, Executive Summary of the Report of the Ad Hoc Task Force on Practice Parameters for Transesophageal Echocardiography. American Society of Anesthesiologists and the Society of Cardiovascular Anesthesiologists, Park Ridge, IL, 1996.



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Finally, Aronson and Cook imply that one cannot separate the contribution of providers and their technology to the process and outcome of anesthesia care. Our study did look at providers working with their technology in the context of actual patient care. Thus, although future studies may be able to look more deeply into the cognition of providers using TEE, our study is fully consistent with the strategy of investigating the process of care in its natural context.

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## Use of Remifentanyl in Patients Breathing Spontaneously during Monitored Anesthesia Care and in the Management of Acute Postoperative Care

*To the Editor:*—Two multi-center studies evaluate the use of remifentanyl in patients breathing spontaneously during monitored anesthesia care and in the management of acute postoperative care.<sup>1,2</sup> Neither addresses the real potential for respiratory depression in a sound manner. The conclusions by Gold *et al.*<sup>1</sup> and Yarmush *et al.*<sup>2</sup> that patients receiving remifentanyl maintained adequate respiratory function during their studies cannot be supported with the reported data.

Adequacy of ventilation was assessed by monitoring respiratory rate and oxygen saturation as recorded by pulse oximetry. A respiratory rate of <8 breaths/min for  $\geq 1$  min, or O<sub>2</sub> saturation <94% on oxygen supplementation were the thresholds for defining respiratory depression, yet both of these values correlate poorly with ventilatory depression.<sup>3-5</sup> Arterial blood oxygen saturations have been shown to be well maintained at the time of peak respiratory depression in patients receiving supplemental oxygen.<sup>6</sup> Under these circumstances, oxygen desaturation may be a late sign of respiratory depression. This failure to detect hypoventilation until oxygen desaturation occurs is an example of the false sense of security seen with pulse oximetry. Normal readings of oxygen saturation in the presence of increased inspired oxygen have been shown to give no information about the adequacy of ventilation.<sup>7,8</sup> Supplemental oxygen may mask carbon dioxide retention.<sup>9</sup> The oxygen supplementation in these two studies was also not defined. The only noninvasive parameters that have been shown to correlate well with depressed ventilation are respiratory pattern, (*i.e.*, paradoxical respiration) end-tidal CO<sub>2</sub>, or, if the depression is severe, level of consciousness.<sup>10</sup> Sedation is a well-known accompaniment of hypercapnia with somnolence and unconsciousness occurring when PaCO<sub>2</sub> levels reach 80 mmHg.

Variations in respiratory pattern may be subtle and difficult to assess. End-tidal CO<sub>2</sub> measurements in the extubated patient monitored *via* nasal cannulae, in our experience, do not always correlate well with arterial PaCO<sub>2</sub>. When the patient is obtunded, nasal breathing is often reduced, and low recordings of end-tidal CO<sub>2</sub> are obtained. On the other hand, sedation level correlates with severe respiratory depression.

Although we have found remifentanyl to be effective in the management of surgical pain and although it is being used more frequently in our clinical practice, careful assessment of the adequacy of respiration is required when using potent narcotics in spontaneously breathing extubated patients. Respiratory rate and pulse oximetry with oxygen supplementation do not meet this requirement. Both the cited studies should have included more precise measurements of ventilatory depression to be able to draw the conclusion that significant depression did not occur. A sedation scale, end-tidal CO<sub>2</sub>, respiratory pattern analysis, and, especially, arterial blood gas analysis should have been considered in the study design if the safety of the technique was the goal of the study. The emphasis on pulse oximetry reinforces the false sense of security of this monitoring technique when supplementary oxygen is being administered.

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