

## CORRESPONDENCE

Anesthesiology  
1998; 88:1122-3  
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### Vigilance—A Main Component of Clinical Quality

*To the Editor:*—We read with interest the article by Weinger *et al.*<sup>1</sup> In particular, the discussion of transesophageal echocardiography (TEE) use in relation to vigilance and workload caught our attention. Vigilance is, for most anesthesia providers, a main component of clinical quality. Vigilance is the Holy Grail of our profession. The suggestion that use of a device, technique, or method of anesthesia leads to decreased vigilance provokes strong reactions because vigilance is so widely recognized as a central theme in practice.

According to the authors, this study of residents coping with TEE and automated records indicates that TEE use increases workload and decreases vigilance. Readers who use TEE doubtless will be disturbed by this interpretation. These readers recognize that the use of TEE requires effort but regard these efforts as amply rewarded by the knowledge gained. Rather than decreasing their vigilance, they consider that the broader and more precise view of cardiac and pulmonary function provided by TEE increases their vigilance by increasing their ability to detect and classify clinically relevant events. They are mindful of evidence that TEE use improves outcomes in cardiac surgery<sup>3-5</sup> and in postoperative settings,<sup>6</sup> facts inconsistent with the idea that vigilance is impaired by its use.

Weinger *et al.* use the term *vigilance* in a technical way. In the psychology laboratory, *vigilance* refers to sustained attention or a state of readiness to detect and respond to certain small changes occurring at random time intervals in a given environment.<sup>2</sup> Accordingly, this psychological sense of vigilance is probably applicable during low tempo, low-signal rate periods.

Cardiac anesthesia typically involves high tempo periods that require *divided* attention, *i.e.*, the smooth, rapid, coordinated switching of attention between different tasks. The processes of divided attention and attention switching during multi-task situations are fundamentally different from sustained attention during low-signal rate periods. Such periods include, but are not limited to, induction, preparation to go on bypass, surgical manipulations like the release of an aortic occlusive clamp, and the period of separation from bypass. How human experts manage the demands of such high tempo periods (and how information technology modulates human expertise and changes these demands) is the subject of intense study in a variety of domains, including anesthesia.<sup>7</sup>

One role of technology is to make the cognitive tasks of anesthesia easier by reducing the uncertainty associated with inferences based on indirect or ambiguous data. This is the purpose of TEE. Intraoperative TEE provides valuable information about cardiovascular anatomy and physiology not otherwise obtainable by inspection or analysis of hemodynamic data. Assembling, testing, and maintaining a view of current and likely future patient state is, we think, what most of our colleagues in anesthesia would regard as vigilance, although many researchers on human cognition in complex domains would use the term *situation awareness* to describe this behavior.<sup>8,9</sup>

In this study, the impact of TEE was assessed by residents with variable exposure to cardiac anesthesia, who were at the early stages of developing expertise in cardiac anesthesia and in TEE. The large variability shown in figure 2 for the TEE task may well reflect their

learning about TEE more than any other factor. This causes us to ask whether the experience of the TEE user determined performance on this task. There are also other factors that may have led to long periods of user focus of attention on TEE. To be used optimally, TEE assessment should be continuously integrated with overall clinical status, surgical manipulations, drug administration, and data from other monitors. The practice of removing the ultrasound machine makes it more likely that the residents would be inclined to devote substantial time and attention to the TEE examination in the period just after induction of anesthesia.

In light of these observations, what are readers to make of Weinger *et al.*'s study? We take this as yet another example of the ways in which human-technology interactions are as complex as the inherent complexity of the domain in which they take place. Direct attempts to disentangle technology from human expertise are unlikely to yield compelling, extensible results in domains where the exercise of clinical skill is so tightly tied to the details of informational tools.<sup>2</sup> The use of TEE (just like any monitor), requires judgment with its application; knowing when to use it is as important as knowing when to stop using it and re-direct attention on a task with a higher priority. In the balance, it is expertise and experience that should be measured with the use of any information technology.

In summary, the vigilance of clinical practice is the construction and maintenance of a view of the patient and procedure that contains the relevant clinical details. TEE use during cardiac anesthesia assists in this cognitively demanding work and, in the right hands, improves vigilance and decreases workload.<sup>10</sup>

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(Accepted for publication December 2, 1997.)

Anesthesiology  
1998; 88:1123-4  
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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.