changes in NO concentration that may occur during the inspiratory phase.

The FiO₂ is limited by all NO delivery systems. With the premixing system, the FiO₂ setting on the ventilator cannot be set at 1.0 because NO enters the system through the high pressure air inlet. With the inspiratory injection system, the ventilator can be set at an FiO₂ of 1.0, but the oxygen concentration delivered to the patient will be less than 100%. For example, an inspiratory injection system that delivers a NO concentration of 20 ppm from a 400 ppm source gas cylinder must reduce the FiO₂ by 5%. Thus, even though the ventilator is set at an FiO₂ of 1.0, the patient only receives an FiO₂ of 0.95. It should also be noted that the inspiratory injection system will increase the tidal volume delivered from the ventilator by 5% under these conditions.

Like Troncy et al., we have been concerned by the generation of NO₂ in premixing systems. However, published data from our laboratory show that this is not problematic at the NO doses currently used (usually ≤ 20 ppm).³ This is consistent with data by Dubé et al.,¹ who have shown similar and acceptable NO₂ concentrations (≤ 1 ppm) for either the premixing system or inspiratory injection system.

It is important to note that the inspiratory injection system favored by Troncy et al. differs from systems that are being developed by industry. One of the systems, the Ohmeda INOvent Delivery System (Ohmeda, Madison, WI) is now available in the United States. This is an inspiratory injection system that is much more sophisticated than that described by us¹ or Dubé et al.¹ The INOvent Delivery System measures the inspiratory flow from the ventilator and precisely injects NO into the inspiratory limb proportional to the ventilator flow to achieve the desired NO concentration. In that way, the delivered NO concentration is constant, regardless of changes in the flow pattern from the ventilator. Preliminary testing in our laboratory shows this system to be precise regardless of ventilatory pattern. It bears emphasis, however, that this system differs from previously described inspiratory injection systems because those systems ( unlike the INOvent Delivery System) do not vary the injection of NO with changes in ventilatory pattern.

It is important that NO delivery systems provide a precise and predictable NO concentration to avoid complications resulting from inaccurate dosing. The delivered NO dose should not change with changes in ventilatory pattern. Dose-response studies of inhaled NO can only be compared if they deliver a constant NO concentration. The only system that we evaluated that met these criteria was the premixing system. Inspiratory injection systems that vary the NO injection with changes in ventilatory pattern may be desirable, pending laboratory and clinical evaluation of such systems as they become commercially available.

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An Algorithm for Quantifying Blood Pressure Lability

To the Editor — Reich et al.¹ have developed and preliminarily validated an algorithm for quantifying blood pressure lability. The problem is clinically significant, and the authors' use of receiver-operating characteristic curves to finetune their system for optimal results seems meritorious.

However, the authors' system does not appear to be an expert system by the conventional use of the term. Consequently, the keyword classification of the article appears incorrect. Further, the first sentence of the conclusion from the abstract, which reads, "One potential application of expert systems to anesthesia practice is a smart alarm to detect blood pressure lability," is a nonsequitur because of this.

An expert system is a computer-based system, typically having certain characteristics: (1) the system performs a difficult task typically done by humans, where experts are provably better than amateurs, (2) the style of programming emphasizes symbolic

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rather than numeric computation. (3) the style of programming attempts to separate actual medical knowledge from program elements determining how that knowledge is used, in part to make system modification and explanation of system behavior easier, and (4) the systems are usually large and complex. Medical expert systems from Mycin\(^1\) to Attending\(^1\) have shared most, if not all, of these defining characteristics.

Running down this list of characteristics, none of these criteria seems applicable to the system developed by Reich et al. First, it is not clear that finding blood pressure lability is difficult or that experts are provably better than amateurs. It could easily be argued that anesthesiologists are better than others at managing or even preventing blood pressure lability, but the author cites no study to support the notion that anesthesiologists are better than nurses or even laymen at defining this lability. Second, the system developed is a numeric algorithm. Third, the system is explicitly referred to as an algorithm, and that approach is antithetical to one separating actual medical knowledge from ‘control knowledge’ or information describing the way the program will execute. Finally, the system developed is neither large nor complex.

The system described by Reich et al. seems totally unlike any expert system in existence, and it seems inappropriate to classify this system as a smart alarm.

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In Reply — We are gratified by Dr. Cohn’s interest in our recently published algorithm for the quantitative measurement of hemodynamic lability. The point that we were attempting to convey in the article is that we developed and validated an algorithm that could serve as a component of an expert system or “smart alarm.” In the paper, we made the circumspect statement that “the potential utility of the lability index algorithm in an expert system (smart alarm) is an important issue and one that cannot yet be answered.”

The definition that Dr. Cohn applies to expert systems is somewhat complex, vague, and does not represent the sole definition of this term. Another authority defines an expert system as “a computer program designed to model the problem-solving ability of a human expert.”\(^1\) Our long-term goal is to incorporate rules, such as the algorithm for quantitating lability, into a rule-based expert system. The algorithm reported in our publication is simply one component of an expert system that is in evolution.

We disagree with Dr. Cohn on certain minor points. In computer science as in medicine, some things are taken as empiric knowledge. For example, it seems fairly obvious to most anesthesiologists that assessing hemodynamic lability is a task that would not be performed well by an amateur. And even the experts have significant performance problems in this area because of imperfect vigilance. Dr. Cohn also implied that a simple system cannot be an expert system. On the contrary, we believe that complexity should be judged not by the internal structure of a system, but rather by the function(s) it performs.

In conclusion, this semantic discussion regarding the definition of an expert system should not obscure the fact that we share a common interest with Dr. Cohn — developing expert systems that will be useful to physicians caring for patients in the operating room and intensive care settings.

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