

## EDITORIAL VIEWS

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## *Training Devices and Simulators*

THE PRACTICE OF ANESTHESIA calls for two virtues and four abilities. The two virtues are compassion toward patients and respect for coworkers, and the four abilities are comprehension of many facts, grasp of complex concepts, manual dexterity, and quick responses. The virtues grow with maturity, but we must endlessly exert ourselves to acquire, maintain, and improve our abilities.

For the induction of anesthesia, we must command facts about anatomy and drugs; apply concepts of pharmacokinetics; display dexterity for intubation; and have quick reflexes, should the patient's anesthetic course require a revised clinical approach. In the 1960s, in their pioneering work with SIM I, a computer-controlled anesthesia simulator, Denson and Abrahamson chose the intubation sequence to demonstrate how a device could help us in learning and practicing this art.<sup>1</sup> They wrote, "The use of the simulator allows for a planned and gradual increase in the difficulty of the problems to be solved . . . almost unlimited repetition of any phase of the procedures to be learned . . . immediate feedback on . . . performance . . . [and] each learner proceeds at his own rate."<sup>2</sup>

In the meantime, others have developed systems designed to better the Four Abilities. Some of these devices, such as CASE, the one presented in this issue of ANESTHESIOLOGY by Gaba and DeAnda,<sup>3</sup> simulate features of the anesthesia work station. These, like the early one by Denson and Abrahamson, are properly named simulators.

Other so-called simulators should really be called training devices, not simulators, because they don't look or feel like an anesthesia setting or a patient. Instead, the inventors of these systems expect us to imagine patient and anesthesia setting. Some training devices are extraordinarily complex, computer-based systems that present facts and concepts, show the responses of physiologic systems, dazzle with pharmacokinetic models, incorporate pathophysiologic reactions, or challenge the student to formulate a clinical plan.

Many modern simulators and training devices rely on algorithms to estimate and display the consequences of a student's course of action or inaction. The prodigious memory of the computer then enables student and teacher to analyze at leisure the outcome of different clinical approaches. Indeed, the programs can demonstrate the dire results of poorly executed procedures or ill-chosen therapeutic plans. This is an important aspect of such simulators and devices, because patients would not volunteer to serve as subjects for such demonstrations. Furthermore, good instructors do their best to avoid bad results when teaching students difficult techniques or complex procedures. Here, simulators and training devices have much to offer: the patient is spared, yet student and instructor can explore in detail the sequence of events that may lead to disaster. Simultaneously, simulators enable them to study signs and symptoms of impending problems, as well as different therapies designed to prevent a debacle.

In anesthesia, the patient suffers the consequences of mistakes made by the student. In some other fields of endeavor students themselves bear the burden. Small wonder that within a year after the Wright brothers in 1908 had taken wing and landed safely, the first flight simulators were constructed. By 1910, the Sanders Teacher, the Billing trainer, and the Walter machine had been introduced for flight training on the

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ground.\*†‡ With hardly an interruption, flight simulators have grown in sophistication year by year. Today, they are marvels in which mechanics and electronics are wed to computer controls that let student pilots forget they sit in a simulator. The student pilot believes that he hears the rumble of jet engines and feels acceleration during simulation takeoff, but, in a "crash," no one is hurt.

When we admire the sophistication of the simulator described elsewhere in this journal and the enormously complex flight simulators, we tend to forget that the need for training devices and simulators goes back much further than aviation or anesthesia. A training device used by Roman soldiers was the quintain, a target at which they tilted their lances from horseback, or on foot, and at times even from boats. The earliest quintains may have been training devices made of nothing more than tree stumps, but in the Middle Ages, they simulated Saracenes with shields and swords.

Even later, the quintain lost its simile with a person but gained an aspect of modern simulators and training devices: feedback. A "tun" of water was attached so that an unskilled rider would be doused when he failed to hit the target properly. An even more realistic feedback was incorporated in the rotating quintain, which came equipped with a crosspiece that would smack the rider as he sped by too close without having hit the quintain just right.<sup>4</sup>

We must doff our hats to the inventors of SIM I. In anesthesia, they were ahead of their time. In a tongue-in-cheek description of SIM I that appeared in *ANESTHESIOLOGY* in 1968, we read: SIM I "might represent man's most impressive attempt, thus far, to manufacture himself from something other than sperm and ovum."<sup>5</sup> And in a similar vein: "The next phase, SIM II, would appear to be an automated trainer to eliminate the need for a flesh-and-blood instructor, and the obvious finale is to simulate the learner as well." After these humorous comments, though, the reporter raised the valid concern about the relationship between cost and effectiveness as a variable determining the life expectancy of SIM.

With the new generation of simulators and training devices, the question of cost will once again be raised. This question has been definitely answered for today's airlines, whose pilots receive a substantial portion of

their training with the help of flight simulators. The airline industry's experience deserves a closer look because a single simulator of a modern passenger jet aircraft may cost in excess of \$10 million. Typically, the major trunk carriers own a simulator for each type of aircraft of which they use more than 20 or so in line operation. If such expensive items can be justified by competitive and cost-conscious companies, the benefit of these simulators must be great. Captain B. E. Beach from Eastern Airlines writes that the simulator allows better training by enabling the instructor to present the student pilot with scenarios that could not be mimicked in a real flight without endangering crew and plane.<sup>6</sup> The responses of the student can be recorded and later replayed for analysis. The simulator offers the advantage that no revenue-producing aircraft has to be removed from service for the sake of training pilots. Captain Beach estimates that Eastern Airlines not only has been able better to train its pilots, but is saving \$70 million annually by fully exploiting the advantages of simulators in its training program.

After reading the paper by Gaba and DeAnda, the doubters will say that 20 years ago Abrahamson and Denson had already presented data claiming that simulators facilitate the learning of anesthesia-related tasks and still the profession was not persuaded of the value of simulators. Now Gaba and DeAnda repeat the claim, but present no better evidence as to the educational advantage of simulation. CASE is probably less expensive than SIM I, but not so cheap that one could afford to roll it out only once every summer for the new residents and then let it gather dust for the balance of the year. And the price tag will not be limited to the acquisition of the system, even with the software provided for free by the generous investigators; instead, one must reckon the expenses for experts to run and maintain the system. In clinical departments without residents, the simulator will be nothing but a novelty, once tried, twice forgotten.

The believers will sing a different song. They will remind us that much has happened in the last 20 years. Computers and simulation have come of age. The young and the young at heart have sat at computer terminals, training devices, and simulators and have great expectations for these new systems. In 1968, there were two lonely investigators. Today, many investigators in anesthesia are at work, several of whom have already published their successes.<sup>7-14</sup> § That body of

\* Harward SM: The Sanders Teacher. *Flight 2*: 1006-1007, 10 Dec 1910

† Billing E: An improved machine for teaching the art of flying without leaving the ground. *British Patent Specification 16773*, 1910

‡ Walters WH: Apparatus for teaching the art of aeroplaning, applicable also for amusement purposes. *British Patent Specification 9950*, 1910

§ Heffernan PB, Gibbs JM, McKinnon AE: Evaluation of a computer simulation program for teaching halothane uptake and distribution (abstract). *Anaesthesia* 37:43-46, 1982

work charts the course in which future developments are likely to move. While Gaba and DeAnda have not yet included pharmacokinetic models, nothing is to stop the incorporation of many models and scenarios in future systems. Moreover, ownership of simulators need not be limited to anesthesia departments. Industry may find it advantageous to use simulators when introducing its customers to new drugs and the ever more complex equipment—machines, ventilators, and monitors—that are finding their way into the operating room.

I look at the work by Gaba and DeAnda and others in the field as the first steps in a new and burgeoning field, not so much as reports of completed projects, but as an appeal to our imagination. This appeal may well prove far more persuasive than the meritorious efforts by Abrahamson and Denson<sup>2</sup> and Gaba and DeAnda<sup>3</sup> to demonstrate that simulators facilitate learning. All of us, from young resident to old practitioner, want to hone our abilities, because we take pride in our profession and we owe exemplary skills to our patients. We all need to enlarge our comprehension of facts, improve our grasp of complex concepts, and increase our dexterity. We all need to remain prepared to recognize that rare event that only quick action can prevent from escalating into disaster. In anesthesia, as in many other fields, training devices and simulators can assist us in fulfilling those never-ending obligations.

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