

Arthur E. Guedel Memorial Anesthesia Center

Robot Anesthesia

By *Merlin Larson, M.D.*

Robots in the operating room are a big item in today's media, and the instrument companies are hard at work to produce useful commercial products. Although robots in surgery and anesthesia might appear to be a new concept, the following narrative reviews the historical development of computerized anesthetics and notes that it is not a truly modern idea. .

The word "robot" comes from the 1920 theatre production *R.U.R.* (Rossum's Universal Robots) by the Czech author Karel Capek. Capek describes the scientist Rossum, who created creatures that were without emotion and lived only to work at one specific task without complaint (*robota* is the Slavic word for subordinate labor or slave). The robots allowed humans to free themselves from manual labor, and this allowed the humans to spend their time "perfecting themselves."

The public became fascinated by the idea of robots and eagerly sought the works of authors who could expand upon the concept. Foremost among these authors were science fiction writers such as Isaac Asimov. Asimov wrote several robot stories between 1939 and 1992, the year of his death. His most widely circulated book was *I-Robot*, published in 1950, in which he describes robots that were indistinguishable from humans. One of his robots, Steven Byerley, was challenged by his political enemies to prove that he was human by demonstrating that he could eat an apple. He refused and instead preferred to show that he could physically injure a human—against the first law of robotics, which stated that robots could never injure a human being. After the demonstration, during which he physically assaulted another individual, it was shown that this "person" was not a human at all, but rather a robot that looked exactly like a human. Asimov was speculating about our era.

As for robot surgery, our so-called robotic surgery is not even close to what Asimov had envisioned. In this regard, the reader will find Asimov's short stories "Segregation" and "Too Bad" of special interest. In "Segregation," a prominent senator with a failing heart has been approved by the "Special Committee" to have his heart replaced by an artificial heart that will last centuries. The senator wants a metallic heart because he envies the metallic robots that are impervious to injury. The metallic robots are called Mettalos and have recently been given civil rights and citizenship equal to humans. The surgeon however wants to

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implant a plastic heart because he is of the opinion that it is more compatible with the fibrous tissue of humans. The senator prevails and they prepare to start the operation. The last paragraph of the story reveals that the Chief Surgeon is a Metallo robot:

The discussion had finished now and the surgeon had to prepare for the operation. He placed his strong hands into the heating oven and let them reach the dull red-hot glow that would sterilize them completely. For all his impassioned words, his voice had never risen, and on his burnished metal face there was (as always) no sign of expression.

In the short story "Too Bad," the physician-scientist Gregory Arnfeld is stricken with cancer but fortunately he has invented a robot miniaturization process that can transform a human-sized robot into a tiny machine to be injected directly into the blood stream. Once in the vascular system, the minirobot searches for cancer cells and kills them with a miniature laser gun. Interestingly, the emerging science of nanotechnology has recently allowed a similar idea to flourish among oncologists.

Asimov's robots *were* the surgeons and thus unlike the robot surgery we have today, which is surgery performed by mechanical arms that are strictly controlled by the (human) surgeon. Anyone who reads the robotic stories of 70 years ago will soon realize that "the future is not what it used to be" (paraphrase from Paul Ambroise Valery) ... our roboticists have failed to live up to predictions. The most highly mentioned robots are the Asimo and Wakamaru made by Honda and Mitsubishi respectively. These robots are a far cry from what Asimov and Capek had envisioned. Remember that both authors mention the years around 2000 when robots would be used for most tedious labor that is now done by humans.

Arthur Guedel and Ralph Waters took the initial steps toward robot anesthesia when they introduced the cuffed endotracheal tube in 1928 (*Anes and Analg* 7:238, 1928). Prior to this time, anesthesia providers were tethered to the head of the patient where they held the ether mask, felt the temporal pulse, and observed the eye signs and respiratory patterns. With a secure airway, the anesthesiologists could move around the operating theatre and observe the operative procedure or even sit by the vaporizers and ventilator that were placed far away from the patient.

Courtin, Bickford and Faulconer accelerated the robot anesthetic movement in 1950 through a paper on the "Classification and Significance of EEG patterns produced by Nitrous Oxide-Ether Anesthesia during Surgical Operations"

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(Proceedings of the Staff Meetings of the Mayo Clinic: 25;197, 1950). In this paper the authors described the progressive changes in the EEG as the anesthetic level deepened and noted that this electrical signal could replace the traditional signs of anesthetic depth as described by Guedel. Reginald G. Bickford was not an anesthesiologist, but he was sufficiently impressed with this discovery that he proposed a system that would automatically control the delivery of ether and/or thiopental simply by responding to the EEG signal alone. He applied for a patent on this device that he called an "Automatic Apparatus for Administering Drugs" in 1950 and was awarded a U.S. patent (#26901787) on September 28, 1954.

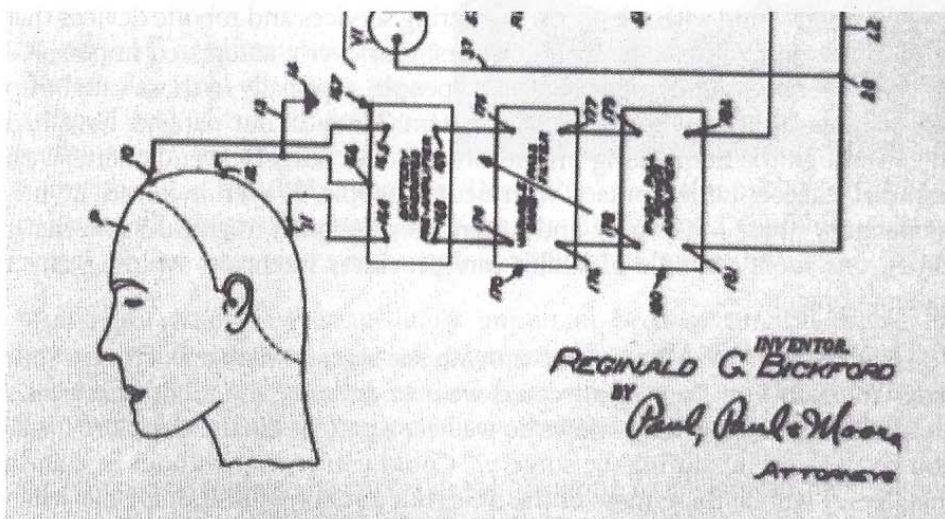


Figure 1: The Bickford patent (1950) described three metal hooks that were placed in the scalp to record the raw electroencephalogram during anesthesia. Public Domain document from the United States Patent Office.

The concept of using the computer to control the anesthetic was taken up by J. W. Bellville, who wrote on this subject in the prestigious journal *Science* (Bellville and Atura, *Science* 126; 827: 1957). In this paper the authors describe improvements on Bickford's system and observed that the EEG signal could be processed and the output used to control the rate of intravenous drugs through syringe pumps. By 1969 Bellville had undertaken a large research project that envisioned the use of small radio transmitters that would transmit the EEG signal, heart rate, blood pressure, et cetera to a control room where two or three anesthesiologists would remotely control eight to ten anesthetics at a time.

In the intervening 50 years, there have been numerous attempts to promote the idea of robot-directed anesthetics. Today we have expanded upon our

definition of anesthesia, so now the contemporary computerized systems have another measure that is supposed to represent the “analgesic” component of the anesthetic. A robot device called “McSleepy” is designed to automatically control the “hypnotic” and “analgesic” components of the anesthetic and eliminate the need for full-time attendance by the anesthesiologist. The device is under review for a patent and some entrepreneur will undoubtedly promote it.

In the words of Yogi Berra: “It is difficult to make predictions, especially about the future,” but *in my opinion*, the robotic anesthetics will fail because the public is fed up with impersonal treatments, especially when we need medical care. By the time they have arrived for surgery, they have been spending hours on the phone speaking with telephone answering services and robotic devices that ask for clear and loud single word answers. Our overly automated impersonal world is becoming a nightmare for many people, especially to those caught up in our fragmented and failed medical system. Many of our patients have had to go through the humiliating preauthorization for surgery, even patients with terminal cancer. Little contact with actual people is ever involved in this preparatory phase for surgery, and a computer designed to give the anesthetic is just one more example of health care providers intent on avoiding direct patient contact.

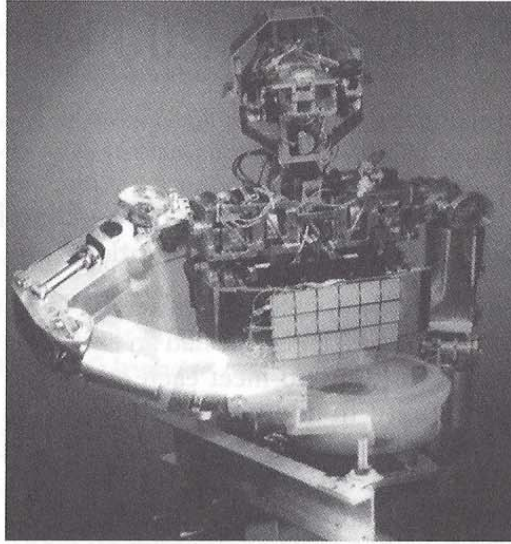
The leaders of the ASA have come up with the slogan “With a Doctor by Your Side, You Can Rest Easy.” How could we ever embrace the robot idea with a slogan like that? How many times do we hear a patient ask the question: “Will you be there for me during the surgery?” Could you answer without hesitation that “Yes, I will be there most of the time, but a robot will fill in for me when I am attending to other patients.” This comment would be similar to an announcement on an airline intercom that the pilot would be in the cockpit most of the flight, but a computer would fly the plane while he was absent. Remember that the pilot does not leave the cockpit, even though the computer is actually flying the airplane.

Computers have lock-ups and power failures, and occasionally have exasperatingly long response times. These problems require a rapid response, within 30 seconds or less, and would require the anesthesia care provider to be so close to the operating room that they might just as well stay in the room from the start to the end.

However, the fundamental problem with robots is lack of *context* (the big picture) and this problem stems from their lack of a human-like visual system. Although it is easy to place several expensive video cameras in a robot, engineering them to actually “see” in the sense of what a human “sees” has been impossible so far. Asimov’s robots had “positronic brains” and that solved the problem for the science fiction writers, but Asimo and Wakamaru, as well

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Figure 2: “Cog” is made at MIT and is capable of rudimentary learning and some elemental interaction with humans. However, a meaningful conversation is impossible and its visual system, although composed of several head-mounted video cameras, is limited to recognition of simple patterns. Photograph courtesy of the author.



as the MIT humanoid robots Kismet and Cog, all lack a visual cortex and thus have only rudimentary vision (Figure 2).

Remember that the IBM computer “Deep Blue” was triumphant in the chess contest with the grandmaster Gary Kasparov (1999), but Deep Blue could not recognize the chess pieces and required a human to move them on the board.

Meaningful vision is fundamentally important because surgical events like removing blood-soaked lap pads, drawing off ascitic fluid, insufflating the peritoneal cavity, and pressing on the carotid sinus are all visual events that we human anesthesiologists can appreciate—but the robot would miss entirely.

We will not be replaced by robots in the operating room—but it might actually be nice to have a small robot nearby to change the IV bags, fill the anesthetic vaporizers or even start a difficult a-line with their specialized infrared sensors. We could even scold it and boss it around and not hurt its feelings ... because it would have none.

Figure 3: Kismet is another robot made at MIT that can respond to human interactions with simple facial expressions. It has six cameras on its face, not all of them in its eyes. Photograph courtesy of the author.

