Surgeon Responsibility in the Era of Change

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A remarkable change in the face of medicine and surgery has occurred in the past decade. The prospect for the future is that even more extraordinary disruptions will occur. Ten years ago, cloning was a theoretical possibility; now human clones exist. Minimally invasive surgery was emerging and robots were speculated upon; now robotic surgery is commonplace. Training was by didactic lectures for knowledge and mentorship in the operating room for technical skills, all provided during a fixed period of time for residency; now simulators for objective assessment of skills and the setting of criteria for performance before allowing a resident to operate on a patient point to the time when a resident trains until he or she is competent, regardless of the length of the "program." Residents will train on "virtual" patients rather than real patients, making mistakes "virtually" before entering the operating room. Work hours are being mandated, perhaps changing medicine and surgery from a profession into a job (How soon before we "punch the clock"?). The responsibility of every surgeon, throughout his or her daily practice has never been more critical in shaping the future of surgical practice than now when the very nature of surgery is changing almost daily. Critical judgment on the validity of the new technologies, and then embracing the change only after evidence proves effectiveness, is an obligation of all surgeons, not just the academics who conduct the clinical trials.

Much of today's turmoil is due to the incredible rate of change in technology. The advances are now occurring exponentially (rather than linearly), and society and healthcare cannot keep up with the pace. A prime example is Dolly the sheep, which confirmed the whole theory of cloning and precipitated a "ban" on human cloning, only to have the ban circumvented, resulting in human clones today. Yet, Dolly is only the tip of the iceberg. Even more profound changes are about to occur, and the medical profession, especially surgery, has not engaged in discussing the solutions to the soon to emerge problems. A few of those issues need to be addressed now, because their remedies will take decades (not months or years) to resolve. To establish credibility and to frame the problems, a few examples of current "over the horizon" technologies include the following:

Computers are rapidly becoming "smarter" than humans are. The human brain computes at $4x10^{19}$ computations per second (cps). The fastest computer, ASIC Red at Sandia National Labs, computes at 35 teraflops/second ($3.5x10^{16}$ cps). That means that in the next 1 to 2 decades, computers (or robots or machines) will compute faster than humans do. Will they be intelligent? And if so, can humans communicate with them? Will they become smarter than humans? Will they remember that humans made them, or even need us humans anymore? If they are "intelligent," can we pull the plug?

Advances in understanding aging led to the discovery of apoptosis factors and to the role of telomeres. By administering antitelomerase (a protein that blocks the enzyme for shortening telomeres during cell division), to a strain of mice, the mice's lifespan is now more than 3 times normal. Can we apply antitelomerase to humans (or should we), and will it result in humans living 2 to 3 times longer than the possible lifespan—living to be 200 to 250 years old? Will such humans be healthy, when will they retire (age 175?), what will happen to the planetary population, etc?

Artificial organs are being "grown" by a number of research teams. Within the decade, it will be possible to grow replacement organs from an individual's own stem cells, so surgeons of the future will only have one operation per organ system—take out the old and replace (not repair) it with an new synthetic organ. When all our organs are replaced with either synthetic organs or smart prostheses, will the person still be human? What will it mean to be human when most of your body has been replaced with synthetic parts?

Research in cognitive science, neural prostheses, signal processing, and robotics has resulted in a number of investigative teams that have successfully implanted a chip into monkeys' brains, connected the chip to a robot arm, and trained the monkeys to feed themselves with the robotic arm simply by thinking. Certainly, the benefit to quadriplegic and paraplegic patients is obvious, but

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should such chips be implanted in healthy people to provide enhanced performance? Will future generations use such chips to directly connect to the Internet or other individuals? Will we "evolve" into a combination of man and machine, or will *Homo sapiens* direct their evolution into a new species?

Although these examples are seemingly science fiction and clearly frightening, remember that at the beginning of 1957 no rockets had been launched, airplanes were just becoming a commercial success, and the moon was "for lovers only." Yet within 12 years, first came Sputnik (1957) and then Man was walking on the moon (1969). Anyone in 1957 who would have predicted a man on the moon would have been dismissed as an irresponsible dreamer, yet our technologies have exceeded even our wildest dreams.

The purpose of these examples is to demonstrate that what was considered "unthinkable" science is soon to become reality. And with these new discoveries, the impact upon society is even greater than ever imagined: people living 200 years, synthetic bodies, direct brain-to-brain communication, humans directing their own evolution, and other even more extraordinary possibilities. Many of them are related to discoveries in healthcare and surgery, and more importantly, require physicians and surgeons in order to implement them. These new discoveries raise severe moral and ethical issues that will take decades to resolve. Science changes faster than societal issues can respond. Now is the time to begin addressing these issues, without rhetoric and hyperbole and in the clear and measured reason of discourse, rather than in a crisis mode with a knee-jerk reaction to a "new" scientific discovery like human cloning.

The above and many other incredible discoveries will occur within the decade, and today's residents and young physicians will have to face (and direct) their consequences, for better or worse. We must encourage debate upon these issues (whenever the opportunity arises, including during daily rounds), even if they may seem somewhat fantastic. Academic surgeons must establish a formal mechanism to raise these issues though presentations at meetings as well as by teaching our students and establishing biomedical ethics curricula within our surgical training programs. Yet even more important is that all practicing surgeons must begin to engage in debate on a national level *at this time*; otherwise, we will abdicate these far-reaching decisions to lawyers, politicians, or even worse, to those who have no understanding of either the science or the humanistic relationships and will establish rules and regulations according to their personal or societal whims or political agenda. This must begin simply, with surgeons acknowledging their own inadequacies and insecurities during the turbulence of change, not being embarrassed to talk about "crazy" ideas in science and medicine, and then taking the personal courage and responsibility to address these seemingly fantastic issues with a measured and concerned attitude, and a willingness to examine and embrace change. For the sake of our children, we must make the "unthinkable" science both thinkable and manageable; otherwise, we will again abdicate these decisions to those who know little and understand even less about the profound implications to mankind.