An alternative point of view: Getting by with less: What's wrong with perfection?

Mark E. Nunnally, MD

Objective: **Predictions about the future impact of technologic and process innovations inspire optimistic visions. Optimism and speculation require a counterweight. Because results often do not turn out as expected, anticipating failure is useful, and anticipating unintended consequences is visionary.**

Measurements: **A history of unfulfilled prognostications was explored with the intent of finding something essential to the complexities of medicine. Do missed predictions signal another side to innovation that also helps us uncover new information about our world?**

Main Results: **Serendipity is an important theme in medical innovation. There is no reason to think this will change. Things do not necessarily go as planned, but often the results are as important as the original prediction was supposed to be. It will not be clear where we end up until we get there.**

Conclusions: **Ideal goals are useful but speculative and subjective. There in fact might be several ideals and contingency is important. The detours and incidental stops on the way to an ideal are more fruitful than the goal itself. (Crit Care Med 2010; 38:2247–2249)**

KEY WORDS: innovation; information; technology; checklist; cognition; decision; prediction; serendipity

"…or even worse it could be perfect."
(William Gibson: The Gernsback continuum. *Burning chrome*. New York, Ace Publishing, 1986)

William Gibson once said that his first thoughts when presented with a new technology were, How can it be put to ill use? Gibson helped make famous the cyberpunk genre, which looked at technology and social order in a way that emulated the famous detective dramas of *film noir*. In other words, things do not necessarily go as planned, new developments unfold in ways never anticipated, and innovation is often accompanied by radical changes in social order.

In a provocative and imaginative essay, Dr. Cobb offers an inspiring vision of the way far-reaching new developments will create a better future in critical care, or reanimation (1). Current or future fans of cyberpunk fiction might see a parallel between halcyon predictions and stories of futures that never materialize. Between the future that is supposed to be and the future that unfolds lies the ultimate learning opportunity.

Like Richard Nixon's 1971 announcement of the war on cancer (2), disputes about the cost and solutions to assure patient safety (3), "silver bullet" cures for sepsis (4, 5), the risks and benefits of perioperative β-blockade (6), or tight glycemic control (7), the future we discover is often different from the one that we have anticipated. Overestimation in medicine leads to uncalibrated prognostication, overapplication of unproven therapy, and sometimes harm. Overestimation stymies creative investigation, channeling scarce resources into those programs that garner the most praise and hyperbole. Overestimation frequently partners with medicine and technology. In the United Kingdom, a multibillion dollar electronic medical records program for the National Health System teeters near implosion. Its promise has not been fulfilled despite the enthusiasm and large sums of money invested (8). Chronic relapsing overexpectation could arise from bad prognostication or unchecked optimism, but more likely the phenomenon is the result of something essential to the complexities of medicine. Do missed predictions signal another side to innovation that also helps us uncover new information about our world?

Science is fundamentally empiric; we change something in the world and watch to see what happens. It is empowering to predict results, but not a loss when things do not work out as predicted. From penicillin (9) to interferon (10), medicine is about serendipity (11). Optimism and speculation thus require a counterweight. Because results often do not turn out as expected, anticipating failure is useful, and anticipating unintended consequences is visionary. Although such consequences can be disruptive, they can also be enlightening.

Many predictions underestimate the tight coupling of cognition, behavior, physiology, and technology. In the example of tight glycemic control, much can be learned from studies investigating the effort and workflow involved in adhering to hyperglycemia protocols (12). Time pressures, reliability and availability of glucometers and infusion pumps, and the integration of pharmacy services and nutrition support influence the implementation of something as simple as titrating a drug. Some of the benefits reported in early studies of tight glycemic control could have come from a change in the cognitive strategies of caring for critically ill patients when clinicians detected sepsis promptly and reliably. Unintended consequences are as important as intended ones. Scientific reductionism separates noise from signal and aids discovery, but noise is a part of the way the world works. It is the manifestation of other interconnected factors. Although

From the Department of Anesthesia and Critical Care, University of Chicago, Chicago, IL.

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For information regarding this article, E-mail: mnunnall@dacc.uchicago.edu

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these factors are dominant in the application of a discovery to the clinical setting, the study of the way individual elements couple and integrate is not a large part of the history of medical science. Yet the future of medical science depends on awareness of such integration.

For tissue healing, advances in genetics open up many possibilities. The prospect of manipulating cell genes and gene expression may change tissue dysfunction but also may cause dysfunction. The recent announcement of the synthesis of a functioning bacterium with a synthetic genome is already generating debates about its impact and application (13, 14). An important part of modern critical care medicine is the support of failing organs to give a patient the chance to heal. Cuthbertson, who first described the stress response, argued that it existed to make healing from tissue injury possible (15, 16). He described a pattern that has been adapted to explain the changes observed after tissue injury (Fig. 1). Recognizing this pattern and mapping it in a critically ill patient are useful cognitive tools to help start or remove therapies. Deviations from the expected pattern such as the triad of hyperglycemia (17), ileus (18), and changes in mental status (19) early in sepsis can signal a need to search for or treat a new diagnosis. The body is its own best therapy when it can heal itself. Attempts to modify the process should enhance rather than simply disrupt or attenuate it. Enhancement of the healing process is considerably harder than disrupting it.

Multiple organ dysfunction is not a healthy state. Patients with the syndrome often die. However, it is likely that this state exists for a reason and its modification might uncover clues as to why it exists. Nature has a head start over science when it comes to disease and adaptation. Dr. Cobb points out that information from the expression of ribonucleic acid might signal patients at risk for complications; it might also signal a response to a new undiscovered source of infection or tissue injury. Although stopping or reversing apoptosis or senescence could change the course of organ failure, it also may unleash new problems. The apoptotic process might be protective as well as injurious (20, 21). Genetic therapies, tissue engineering, and novel approaches to intracellular signaling and expression impact disease in ways we can hardly predict.

Technology, often a partner in medical innovation, can also be a problem, as the National Health System can attest. Few studies have examined the integration of technology and cognition, yet logic suggests that we understand workflow and decisionmaking in health care before imposing on it complex information technology. Well-designed devices that improve easy access to information are welcome, as demonstrated by the popularity of the iPhone. Unfortunately, the design philosophy that makes the iPhone useful is not common in medical technology, including information technology (22). Instead, tragic cases point out the flaws in healthcare technology that can have costly (23) or dangerous (24) consequences. The problem with technology-centered advances is that they are technology-centered. Designs that accommodate workflow and cognition while also enhancing existing processes are few. Instead, new technologies are shoehorned into existing systems. The cyberpunk authors were interested in breakdowns in social order. They understood that what existed before technology is more complicated and fragile than many believe. As information technologies proliferate and political imperatives spur their adoption in medicine, researchers will be wise to dissect the effects the innovations have on existing workflow and social order.

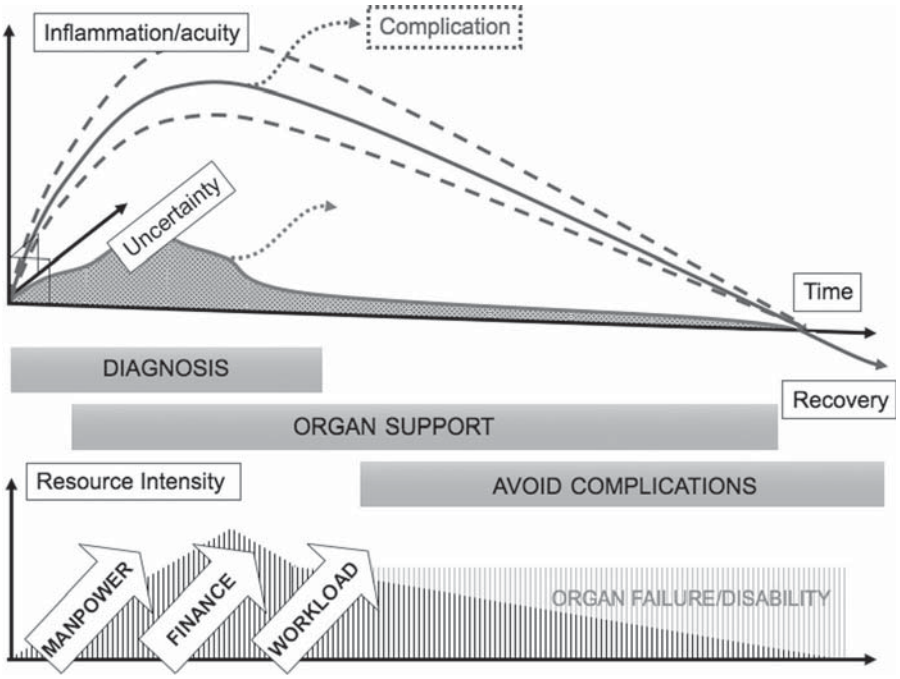

Figure 1. An adaptation of Cuthbertson's stress response curve (15, 16). Critical care is a dynamic group of activities centered around changing patient physiology. Any therapy or manipulation, be it drugs, organ replacement, safety checklists, or other interventions, will cause perturbations in a series of tightly coupled interactions. Time pressures, resource constraints, changing uncertainty, and the focus on care activities, among many things, influence outcomes.

Human tendency is often vilified, even in the titles of major safety reports (25). Performance variability is generally looked on as a bad thing, although definitive evidence for this judgment is lacking. Variability is a good thing under many circumstances; it is linked to creativity. Often devices like checklists are perceived as a means of standardizing and improving complex processes. Such techniques have their place, but any benefit will result from more than the physical act of checking a box. An apocalyptic future can be imagined in which the physician spends his or her entire day checking boxes and paying attention to a computer rather than caring for patients. Unintegrated mandates proliferate quickly in medicine. When does the marginal benefit of another checklist or algorithm become less than the costs of hassle, interruption, cognitive dissonance, and expense? Checklists, compliance mandates, and quality metrics constrain practice, sometimes for the better, but also potentially for the worse. Like with the case of tissue healing, the questions that arise from the implementation of checklists are more important than the

interventions themselves. Understanding when performance variability is helpful or that two completely different methods might both effectively treat a critically ill patient is an underexplored, underreconciled, and underappreciated part of the delivery of health care. Before we standardize, we should understand our own diversity.

Dr. Cobb's vision is inspiring. He uses important discoveries, including his own impressive research, to build a vision for the intensivist community to improve patient outcomes. His work is a fitting tribute to the man in whose honor it was originally scripted, Dr. Peter Safar. I hope many of his visions materialize, and I like his optimism. I am also getting ready for what might happen if such a future is not realized—as has happened before. Cold fusion was soon to change our world in 1989. Artificial hearts have been on the verge of changing heart failure care since the early 1970s (26). When a sheep was cloned in 1996 (27), cloning tissue, organs, or even people was predicted to change medicine. Any or all of these predictions could still come true, but they have not yet followed the scripts written for them. At the same time, we are left with a wealth of new knowledge as a consequence. Advances in DNA sequencing, discoveries in RNA processing, and new developments in left ventricular assist devices followed from the original initiatives, even if they were not exactly as intended.

I find potential in Dr. Cobb's words. Even if the future is not precisely what he hopes it will be, I am excited to think about what might be learned along the way. Many incidental discoveries are more beneficial than the project targets themselves. Dr. Cobb discusses future insights that might be obtained from the deviations in a normal healing trajectory; this point is particularly intriguing because good medicine is about pattern recognition. One of the difficult daily decisions in the intensive care unit is whether to give patients more therapy–more resuscitation, antibiotics, organ support—or to discontinue unnecessary support by liberation from mechanical ventilation, antibiotics, or invasive catheters. Using a new discovery to enhance the decisionmaking process is innovation. Serendipity is the upside of things not going as planned and an insight into how complex systems work. It will not be clear where we end up until we get there.

In "The Gernsback Continuum," the protagonist battles visions of an idealistic and forgotten vision of the future. He muses that things could be worse or, worse still, perfect. What is wrong with perfection? First, we do not know nearly enough about our world to speculate on its perfection. Second, perfection suggests one ideal; there might be several. Third, the blind pursuit of perfection ignores contingency. Finally, the detours and incidental stops on the way to an ideal are more fruitful than the goal itself.

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