The Operating Room of the Future Versus the Future of the Operating Room

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KEYWORDS

• Integrated system • Informatics • Neuronavigation • Tractography
• Corridor surgery • Cellular imaging • Robotics • Iterative learning

KEY POINTS

- The operating room of the future will be an informatics-driven platform.
- The information will be collected seamlessly in the background and provide for iterative learning.
- The information must be available in real time.
- Quality assessment and planning are integral features in informatics-based patient care.
- Advanced robotic optical imaging in synergy with real-time, integrated imaging can potentially reduce risk associated with surgery.
- Patient-centered cellular informatics in association with this operative paradigm will be the future of targeted therapy, which will occur *in situ* to restore the state of health.

Video content accompanies this article at http://www.oto.theclinics.com.

INTRODUCTION

The art of surgery has evolved dramatically over centuries in hopes of progressively becoming a science. Its precision will continue to evolve and refine as critical knowledge is acquired, curated, and shared, to develop predictive and iterative patterns of learning, thereby delivering the fundamental requirements to minimize variance and enhance safety. By way of analogy, the aeronautic industry has been subject to the

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Abbreviations	
CS-m	Conventional stereoscopic microscope
CT	Computed tomography
CTA	Computed tomography angiography
3D	Three dimensional
DoF	Depth of field
DTI	Diffusion tensor imaging
FoV	Field of view
HD	High-definition
NA	Numerical aperture
ROVOT-m	Robotically operated video telescopic microscope
VoV	Volume of view
VT-m	Video telescopic microscopy

same evolutionary process, and there is much to be learned from it. Much like in medicine, the individual patients' frustrations have remarkable similarities to passenger service frustrations, such as unanticipated events, delays, circumstances (eg, weather), escalating costs, and growing bureaucracy.

However, a key difference when comparing the patient-passenger paradigm is the overall safety profile. The incidence of airline crashes relative to the number people transported shows a remarkable safety record across multiple pilots, multiple airlines, and multiple countries, resulting in minimal variance and remarkable safety.[1,2] In comparison, the variance in surgery can be significant. However, unlike the airline industry, the mechanisms to quantitate and report such variances remains primitive. As the era of the risk-and-reward economy in medicine begins, this is bound to change. Rather than being financially rewarded for crashes (complications) that lead to more billable procedures, clinicians will now be economically penalized as they transition to a risk-shared economy. So what does this mean for the future of the operating room (OR)?

A period of transformative change is beginning, much like the airline industry experienced decades ago. The initial efforts to fly with minimal instruments and undertake uncoordinated exploratory routes without critical preflight and intraflight information were replaced when the high risk of catastrophic events was realized. The economic implications of a single crash and loss of lives became apparent and paramount in creating strategies that mitigated the exorbitant human and economic costs. To look past the human elements, how many seats would have to be filled and purchased to pay for the financial costs associated with a single crash? This provided key motivation to develop both technology and integrated processes to mitigate risk by creating a high-reliability system (**Fig. 1**). The art of flying evolved rapidly into a precise aeronautic science that has become inherently and inexorably dependent on the knowledge that is acquired, curated, and shared to develop predictive patterns to facilitate iterative learning. The very act of a crash is objectively captured and carefully scrutinized in the black box to provide for iterative learning.

As medicine enters an era in which risk is of paramount concern, the same evolution is anticipated to occur. As such, the OR of the future is rapidly transitioning from an exploratory, experiential learning environment (the art of surgery) to an information-driven, iterative learning environment with incremental precision and predictive learning. Explicitly, the authors believe the future OR to be a vital hub of real-time physiologic, anatomic, and pathologic tissue interrogation that is contemporaneously and seamlessly collected in the background, much like the manner in which the e-commerce collects our individual consumer habits to design precision marketing to acquire and curate critical information, then act on it without the consumers leaving their homes.