Notable Grand Rounds

of the

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Department of Surgery

Wayne State University
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Detroit, Michigan, USA

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THE FUTURE OF SURGERY

October 22, 2025

About Notable Grand Rounds

These assembled papers are edited transcripts of didactic lectures given by mainly senior residents, but also some distinguished attending and guests, at the Grand Rounds of the Michael and Marian Ilitch Department of Surgery at the Wayne State University School of Medicine.

Every week, approximately 50 faculty attending surgeons and surgical residents meet to conduct postmortems on cases that did not go well. That "Mortality and Morbidity" conference is followed immediately by Grand Rounds.

This collection is not intended as a scholarly journal, but in a significant way it is a peer reviewed publication by virtue of the fact that every presentation is examined in great detail by those 50 or so surgeons.

It serves to honor the presenters for their effort, to potentially serve as first draft for an article for submission to a medical journal, to let residents and potential residents see the high standard achieved by their peers and expected of them, and by no means least, to contribute to better patient care.

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The Future of Surgery

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Editor's Note: *This paper summarizes a Grand Rounds talk on October 22, 2025 at the Ilitch Department of Surgery, Wayne State University School of Medicine. The talk was based on an unpublished draft manuscript of the same title, co-authored by Drs. D. Weaver, E. Pontes, D. Edelman, K. Koya, and Mr. Ellis. A copy of the draft manuscript, with references, may be provided on request to the Dept. of Surgery on the understanding that it is not for further distribution.*

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Introduction

The future of surgery is arriving more rapidly than most of us imagined. Developments in artificial intelligence, robotics, and genomics are advancing at a pace that challenges traditional professional rhythms of validation, regulation, and adaptation. Innovation cycles that once spanned decades now unfold in years—or even months—compressing the distance between laboratory discovery and operative application. The question is no longer whether technological transformation will redefine surgical practice, but how soon and to what extent.

Any attempt to describe that future must be speculative, yet informed speculation is essential. Surgeons, educators, and trainees need to engage these possibilities now, while there is still time to shape them, rather than respond too late when they become *faits accomplis*. The purpose of this essay, therefore, is not prediction but preparation—to encourage reflection and debate on what it will mean to practice, teach, and preserve the essence of surgery amid accelerating change.

Historical Foundations of Modern Medicine

To appreciate how unusual our moment is, it helps to recall the last comparable period of epochal transformation in medicine, roughly a century and a half ago. The late nineteenth and early twentieth centuries saw three sequential revolutions that collectively defined "modern" medicine.

The first was the laboratory revolution of Louis Pasteur and Robert Koch, whose experiments in bacteriology established germ theory and gave disease a microbial identity rather than a mystical or humoral one.

The second was the bedside revolution led by William Osler at Johns Hopkins, who moved students out of lecture halls and into hospital wards, insisting that they learn from direct patient observation. Osler fused science and humanism by teaching that physicians must study not only the disease but the patient who bears it. It was Osler who named the new medicine "modern" medicine.

Finally came the educational revolution of Abraham Flexner. His 1910 report condemned commercial medical schools and required that legitimate education be university-based, scientifically rigorous, and clinically grounded. Flexner institutionalized the Hopkins model as the standard for modern medical education.

These complementary revolutions collectively took more than half a century to mature. By contrast, the current technological upheaval is compressing similar degrees of change into a single generation.

The Acceleration of Innovation

When the FDA first cleared Intuitive Surgical's *da Vinci* robot in 2000, few anticipated how swiftly it would evolve. Within twenty-five years, five major generations have appeared, each refining visualization, precision, and ergonomics. Competing systems now proliferate: Intuitive's Ion for bronchoscopy, Johnson & Johnson's Monarch, Medtronic's Hugo, and CMR's Versius, covering urologic, gynecologic, colorectal, and thoracic applications. Competition from Asia is poised to shorten the innovation cycle even further.

Artificial intelligence has advanced on an equally steep trajectory. OpenAI's GPT-3 debuted in 2020; GPT-4 followed in 2023, and GPT-5 arrived less than two years later, each generation representing a quantum leap in reasoning and multimodal capability. The consequence of acceleration for medicine is profound: the evidence base, regulatory frameworks, and training structures that safeguard patient care can scarcely keep pace with the tools they are meant to govern.

Regulatory mechanisms remain largely retrospective. The FDA's predominant clearance pathway, the 510(k) process, determines approval by demonstrating "substantial equivalence" to prior devices rather than by prospective clinical trial. Even newer approaches—such as Predetermined Change Control Plans, which allow continuous software updates—still rely on validation of prior versions rather than real-time assessment of adaptive performance. In effect, regulation looks backward while technology races forward, leaving clinicians to practice in the widening gap between them.

The economic and professional consequences are considerable. Hospitals risk millions when a robotic system purchased today is superseded tomorrow. Leaders face pressure to justify ROI amid fast cycles and uncertain payback windows. Surgical teams face repeated cycles of retraining, new workflows, and shifting standards of care. The psychological burden of perpetual adaptation is itself becoming a defining occupational hazard.

In this environment, institutional readiness can no longer be regarded as a fixed achievement but as a moving target. Success will depend on cultivating ecosystems of continuous learning, adaptive credentialing, agile governance, and robust psychological support for practitioners.

The central dilemma is of speed versus safety. If innovation outpaces validation, do we press forward and accept the attendant risk, or slow the pace and risk denying patients timely access to lifesaving advances? How the surgical profession negotiates that tension will shape not only its future identity but the moral landscape of medicine itself.

Surgical and Clinical Applications

Technological change has now reached the operating room. What was once confined to pilot projects in elite centers has entered routine clinical use across disciplines and hospital settings.

In emergency general surgery, robotics—long associated with planned, elective operations such as prostatectomy, hysterectomy, or colorectal resection—has proven its value in urgent cases including cholecystectomy, incarcerated hernia repair, and acute diverticulitis. Recent studies demonstrate reduced complication rates, shorter hospital stays, and lower conversion to open procedures. For frail or multimorbid patients, those advantages can determine the difference between recovery and prolonged disability.

A landmark example is the REAL trial, a multicenter comparison of robotic and laparoscopic approaches for rectal cancer resection. Although not without methodological challenges, the trial suggested that robotic surgery achieved higher rates of circumferential margin clearance, particularly in anatomically constrained male pelvises, enabling more precise, nerve-sparing dissection. These data mark the transition from hypothesis to peer-reviewed evidence: robotic platforms can confer measurable benefit for defined patient populations.

Institutional experiences reinforce the trend. Houston Methodist has positioned itself as a surgical robotics and AI “moonshot” center. Sentara Health in Virginia has extended robotic coverage into emergency scheduling while using ambient AI documentation to reduce clinician burnout. Christ Hospital in Cincinnati has integrated AI-supported triage and robotic surgery for oncologic cases. At Mayo Clinic, nearly one hundred AI algorithms are operational, including systems for automated surgical-site infection detection. Adoption is flattening across the diffusion curve: community hospitals now regard robotics and AI as indispensable rather than experimental.

For trainees, this shift entails a new professional identity. Residents must now master open, laparoscopic, and robotic techniques while learning to interpret AI-driven decision support, interact with intelligent records, and collaborate with engineers and data scientists. Radiology and pathology have already made similar transitions, as image-analysis algorithms increasingly match expert-level performance. Surgery is next, moving rapidly toward AI-driven pre-operative planning, intra-operative decision support, and post-operative risk prediction.

Ambient Intelligence and Decision Support

The transformation extends beyond the robot itself to the operating environment. The intelligent operating room—sometimes called ambient intelligence—represents the next frontier. In such spaces, networks of sensors, cameras, and algorithms continually observe and interpret events, turning the OR from a passive setting into an active participant in surgery.

High-resolution imaging systems now track instrument movement at dozens of frames per second, detecting bleeding, identifying anatomical landmarks, and predicting procedural steps. These capabilities create a real-time safety layer that complements rather than replaces the surgeon’s eyes and judgment.

Natural-language interfaces are emerging as well. Surgeons can issue voice commands—“clamp,” "cut," "zoom"—and the system responds hands-free. Prototype "AI circulators" retrieve patient data or anticipate instrument requests.[25] Predictive analytics operate in parallel, integrating physiologic and anesthetic data to warn of complications such as sepsis or anastomotic leak while the procedure is still underway. The potential to intervene before deterioration becomes clinically apparent redefines intra-operative vigilance.

Ethics and Equity

Technological capability now advances faster than moral and regulatory reflection. Innovation seldom waits for consensus; ethical reasoning follows rather than precedes new tools. The profession must therefore engage the ethical terrain not to impede progress but to guide it toward justice and humanity.

Equity is the foremost concern. Algorithms trained on narrow or biased datasets may underperform for women, minorities, or rural populations, widening existing disparities. Similarly, the cost of AI-integrated surgical systems and robotic platforms threatens to widen the gap between resource-rich academic centers and under-funded community hospitals. Unless deliberate measures ensure representative datasets, subsidized dissemination, and fair reimbursement, innovation may amplify rather than diminish inequity.

Consent and data sovereignty are emerging challenges. Continuous, ambient data collection in surgical environments raises questions about awareness, autonomy, and control over the digital record. Transparent communication, opt-in protocols, and institutional safeguards will be required to preserve ethical integrity.

Finally, accountability remains central. When an AI system errs, clinicians must still bear ultimate responsibility, and algorithmic reasoning must be explainable in human terms. Transparent governance, clear liability rules, and real-time auditing are essential for public trust.

Training the New Surgical Team

The apprenticeship model—"see one, do one, teach one"—is no longer sufficient in an era of robotics and artificial intelligence. Surgeons now require fluency not only in manual technique but also in algorithmic reasoning and systems thinking. Training programs are beginning to integrate AI literacy into residency curricula, preparing physicians to evaluate and supervise intelligent systems.

At Cleveland Clinic, dedicated AI-education modules introduce residents to algorithm validation and critical appraisal. At New York University, surgical teams work with data scientists and human-factors engineers to optimize workflow design. These initiatives signal a transition from the solitary expert toward a hybrid-intelligence team in which human judgment and machine precision coexist.

Professional societies are codifying this expectation. The American College of Surgeons urges formal instruction in algorithm validation and human–machine collaboration. SAGES and ASGE consensus guidelines similarly call for AI literacy as part of certification standards.[42] Simulation platforms that combine virtual-reality environments with AI-driven feedback are becoming core tools for surgical education.

The deeper pedagogical question is what should remain uniquely human. Should programs still emphasize knot-tying and suturing when machines may soon exceed human dexterity? Or should emphasis shift toward empathy, communication, ethical reasoning, and crisis leadership—the enduring attributes of surgical presence when technology fails?

Without deliberate rebalancing, training risks producing surgeons competent in many domains but expert in none. Curricula must be intentionally designed for the world that is coming, not the one that has passed.

Future Scenarios and Postmodern Medicine

One near-term scenario is remote and distributed surgery. Bandwidth and latency improvements already enable surgeons to operate from afar, directing robots in another hospital or even another state. A rural patient could undergo a laparoscopic procedure locally while a tertiary-care specialist supervises or performs it remotely. Such telepresence could dramatically expand access to high-level surgical care if regulatory and infrastructure barriers can be resolved.

Autonomous systems are also advancing rapidly. Researchers at Johns Hopkins and Stanford have trained robots to perform surgical tasks independently, including portions of laparoscopic cholecystectomy, with 100 percent technical success in animal models. As algorithms become more sophisticated, systems may soon undertake limited human procedures such as trocar placement or vessel sealing.

At the same time, regenerative and molecular medicine are reshaping the need for traditional operations. Coronary artery bypass grafting, for example, may decline as gene therapy and vascular tissue engineering restore blood flow without open surgery. Bariatric procedures could wane as effective metabolic drugs and genetic treatments take hold. Meanwhile, bionic and digital medicine are creating wholly new forms of surgical practice—ranging from robotic prostheses controlled by neural interfaces to implantable micro- and nanorobots that repair tissue internally.

Together, these forces signal a shift from the "modern medicine" of Osler and Flexner to a postmodern medicine in which boundaries between biology, engineering, and computation are porous. The surgeon of the future will be less a manual operator than a conductor of a complex orchestra of human and machine intelligences.

Institutional Responsibility and Collaboration

These transformations extend beyond individuals to institutions. Academic medical centers must choose whether to lead or follow. Nowhere is this choice more critical than in Detroit, where the Wayne State University School of Medicine (WSU) and the Detroit Medical Center (DMC) together possess the components of a next-generation translational ecosystem.

The Smart Sensors and Integrated Microsystems (SSIM) Laboratory, under Dr. Auner, developed the first pediatric robotic procedure in collaboration with Dr. Klein at Children's Hospital of Michigan, and is now advancing AI-enabled Raman probes for intra-operative tumor detection. Dr. Pandya has published on real-time fatigue monitoring during robotic surgery, while Dr. Batchu's group is developing microfluidic tumor spheroids for advanced cancer therapies—innovations that could position Detroit as a national model for intelligent surgery if institutional collaboration overcomes historic division.

Closing Reflections

The transformation of surgery rests on three intertwined themes: acceleration, redefinition, and equity. The pace of change is unprecedented; the professional identity of the surgeon is being redefined from individual craftsman to orchestrator of hybrid teams; and equity remains the moral compass without which innovation risks exploitation.

If DMC and WSU—institutions once divided by mission and governance—align around a shared commitment to humane, technologically advanced care, Detroit can become a beacon of cooperative renewal. For the next generation of surgeons, the challenge is not to resist these forces but to guide them, uniting technological intelligence with moral intelligence so that surgery's next evolution also becomes its truest expression.