The Tipping Point of Medical Technology: Implications for the Postpandemic Era

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GLOSSARY

3D = 3-dimensional; **"Act"** = Coronavirus Preparedness and Response Supplemental Appropriations Act; **APM** = alternative payment model; **CMS** = US Centers for Medicare & Medicaid Services; **COVID-19** = Coronavirus Disease 2019; **EHR** = electronic health record; **EMR** = electronic medical records; **IA** = improvement activity; **ICU** = intensive care unit; **MIPS** = Merit-based Incentive Payment System; **NQF** = National Quality Forum; **NSQIP** = National Surgical Quality Improvement Program; **PPE** = personal protective equipment; **QCDR** = Qualified Clinical Data Registry; **RPM** = remote patient monitoring; **SARS** = severe acute respiratory syndrome; **SARS-CoV-2** = severe acute respiratory syndrome coronavirus 2

The unprecedented challenges of Coronavirus Disease 2019 (COVID-19) have pushed the limits of medicine and health care over the tipping point of what we thought imaginable, forcing solutions to problems that previously mired rapid progress. Nowhere has this been more apparent than in technology, where both its accelerated advances and shortcomings have come into sharp contrast during the current pandemic. Whereas classic infection-control and public health measures were used during the severe acute respiratory syndrome (SARS) epidemic in 2003, COVID-19 provides the opportunity to explore the potential of new digital technologies, including big data analytics, artificial intelligence, blockchain technology, and the Internet of Things.[1]

Among the many available digital technologies, O'Reilly-Shah et al[2] in this issue of *Anesthesia & Analgesia* address not only the potential benefits but also the barriers to adopting health informatics for patient care during the COVID-19 pandemic.[2] They review concerns around current gaps in technology, including data privacy and ethics, we well as data silos and sharing. They highlight the lack of data infrastructure and interoperability as barriers to patient care and public health efforts during the pandemic. A recent study similarly observed that barriers to public health agencies receiving hospital-level data on COVID-19 patients included the inability to electronically receive data, interface-related issues, difficulty extracting data from the electronic health record (EHR), and different vocabulary standards.[3]

O'Reilly Shah et al[2] also highlight concrete examples of the pandemic pushing the creative edges of technology.[2] Like other authors,[4] they note the proliferation of clinical decision support tools such as best practice alerts, order sets, and dashboards designed to track real-time COVID-19 updates in a hospital.

While O'Reilly-Shah et al[2] review the advantages and gaps currently existing specifically in clinical informatics,[2] technology—in all of its forms—is rapidly evolving to address the pandemic. The apparent transition to the postinitial surge phase of the COVID-19 pandemic serves as an inflection point to reflect on the potential technological contributions of anesthesiology and anesthesiologists. Considering the expansive array of digital technologies available to contemporary health care, we take the liberty in this current editorial to discuss the anesthesiologist's optimal role in this broader arena.

Indeed, equally relevant to any discussion on technological innovation are the creative nondigital solutions that have been implemented during the initial COVID-19 surge. Many of these were developed by necessity, such as alternative personal protective equipment (PPE) options and reprocessing and sterilization techniques for N95 respirator masks. Critical

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shortages of PPE-motivated amateurs and expert manufacturers to utilize 3-dimensional (3D) printing to create medical supplies like face shields, face masks, and nasal swabs. Novel medical technologies like intubation boxes to minimize aerosolization, splitting ventilators, and new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) testing and treatment options are continually being developed.

The specialty of anesthesiology has a strong track record of innovations in medical device technology—witnessed again with COVID-19. We posit, however, that the current pandemic offers a unique opportunity to contribute to emerging digital technologies that have not been conventionally considered part of the purview of anesthesiology. This includes expanding our roles in telehealth platforms and remote monitoring and surveillance in the inpatient and outpatient settings, thereby adding significant value to the continuum of care through perioperative medicine. As we expand these technologies, it will be incumbent upon us to apply equally innovative metrics to measure the clinical and quality outcomes of these interventions in the perioperative setting.

TELEHEALTH VISITS AND REMOTE PATIENT MONITORING

One of the most striking transformations during the current pandemic has been the rapid adoption of telehealth and telemedicine. Before the emergence of COVID-19, despite impressive advances in video and mobile technology, telehealth progress was stymied by highly restrictive stipulations by the US Centers for Medicare & Medicaid Services (CMS), state boundaries, and poor reimbursement. The pandemic has spurred federal and state regulators to level the playing field by reducing barriers to telehealth adoption, including reimbursement parity laws and relaxing state geographical restrictions. The expansions also included several CMS emergency initiatives that expanded Medicare and Medicaid coverage, increasing the modalities and sites of coverage, such as personal residences, federally qualified health centers, and rural clinics.[5] Congress passed relief bills allowing the US Department of Health and Human Services to approve telehealth grants, and the Federal Communications Commission started a COVID-19 Telehealth program. States followed suit with emergency directives to increase telehealth access and coverage.

State-level, COVID-19–related shelter-in-place mandates prompted rapid implementation efforts highly relevant for the vast majority of specialties, including anesthesiology.[6–8] As early adopters of telemedicine in the perioperative setting, our respective health systems realized a marked increase in opportunities to expand virtual preoperative consultation for patients. Facilitating the expansion of telehealth platforms simultaneously assisted staff and patients to adhere to statewide shelter-in-place mandates, reduce risk of exposure, and preserve PPE during the initial surges of the pandemic.[9]

The preoperative anesthesia clinics at our health systems rapidly adapted our existing telehealth workflow, allowing us to continue to risk stratify, optimize, and prioritize surgical cases when elective procedures were postponed. Anecdotally, one of our institutions implemented an increase from 30% audiovideo visits to nearly 100% within one business day. Our experiential learning from this radical transformation reflects what others have reported about their telehealth experiences during the pandemic.[6] The challenges, opportunities, and solutions experienced by our preoperative medicine and pain medicine clinics during this transition are listed in Table 1.

The initial COVID-19 pandemic surge and shelter-in-place mandates reduced our capability to perform a conventional physical examination of our patients, leading to the creative application of remote patient monitoring (RPM) and surveillance technologies. In the ambulatory setting, we shifted our reliance on patient-entered outcome data to remote monitoring in several scenarios, including continuous glucose monitors for glycemic control of insulinoma patients; Bluetooth weight scales for patients with congestive heart failure; consumer actigraphs to evaluate activity levels; and Bluetooth-enabled blood pressure cuffs to titrate alpha-blockade of pheochromocytoma patients.

Within the hospital, remote surveillance offers unique abilities to safety monitor patients in non–intensive care unit (ICU) settings while conserving scarce medical equipment and PPE. Safavi et al[10] describe the prerequisites and limitations for proper remote surveillance so clinicians can identify patients at risk for physiological deterioration.[10] Their technological blueprints illustrate the importance of electronic medical records (EMR)–based database structures and data lakes and the design challenges to assure reliable information access and interpretation.

Knowledge gained from the inpatient setting has direct application for monitoring infectious disease outside the hospital using patient self-entered clinical data. For example, institutions across the country have implemented EHR-embedded tools to remotely monitor asymptomatic, COVID-positive patients at home[11]; and to detect physiological deterioration with remote monitoring (pulse oximetry and temperature), asynchronous questionnaires, and video visits to advise a return to the hospital or clinic only if a patient becomes febrile or dyspneic or exhibits oxygen desaturation.[12]

Table 1. Lessons Learned From Rapid Telehealth Implementation for Anesthesiology-Led Clinics

Challenge	Opportunity and/or Resolution
Reimbursement for virtual visits	Temporary waiving of requirements with "Act"
Patient's lack of adequate Internet access or usable electronic devices	Patient education and intake materials sent ahead of appointment Use of additional modalities approved by the "Act" (eg, Apple FaceTime, Facebook Messenger Video Chat, Google Hangouts Video, or Skype)
Enrolling patients into electronic health portal and access to virtual visits	Patient education team increased outreach and enrollment efforts
Access to interpreter services	Partnered with hospital interpreter services for virtual visits
Training and resources for virtual visits	Remote access training and home laptops coordinated for clinic staff
Shelter-in-place mandate and personal protective equipment conservation	Preoperative and pain virtual visits offered to all patients
Preoperative diagnostic testing (eg, laboratory testing, electrocardiogram, and/or imaging)	Obtained prior medical records to limit new testing Testing deferred to morning of surgery when possible Coordinated with primary care physician if needed before surgery
Inability to obtain reliable remote physical examination and vital signs	Airway examination conducted through virtual visit Vital signs recorded from patient's home devices if possible Several in-person visits to auscultate new cardiac murmurs Consideration of long-term facilitated telemedicine options
Patient experience	Initiated ongoing patient experience survey with preliminary positive results
Staff experience	Staff expressed ease of learning telehealth platform and satisfaction at work-from-home safety measures

Abbreviation: "Act," Coronavirus Preparedness and Response Supplemental Appropriations Act.

This progress made in COVID-19 outpatient remote surveillance will advance postdischarge follow-up in the perioperative setting. There is growing impetus for surgeon-anesthesiologist to collaboratively participate in the "hospital-at-home" paradigm.[13,14] Improving effectiveness and efficiency through clinical pathways will also reduce hospital-acquired infections and other complications, thereby reducing length-of-stay—all of which are paramount as we define the "new normal" in perioperative care. Therefore, current successful experience with remotely triaging and managing asymptomatic COVID-19 patients can pave the way to widespread future RPM implementation in the postoperative discharge setting. Anesthesiologists are well-trained to triage and to manage postsurgical patients using RPM technologies, and can thus potentially serve as reliable touchpoints for the 7- or 14-day transition of care visit in the outpatient setting.

Similar to EHR platforms, however, telehealth and RPM technologies have unresolved limitations. Issues of data privacy and sharing, along with the shortcomings of digital infrastructures exist in these areas. We cannot ignore the digital divide and inequity of adoption that can occur along racial, ethnic, and socioeconomic lines, including limited access in underserved areas or among vulnerable patient populations.[15] Public policy must support sustainable reimbursement models for virtual health visits. Finally, robust outcomes research is necessary to assess the clinical effectiveness of these new technologies for patient care. While COVID-19 certainly has convinced some previous skeptics of the relevance and safety of telehealth, O'Reilly-Shah et al[2] aptly remind us to identify and address its limitations.

IMPLICATIONS ON THE DELIVERY OF CARE: REDESIGNING QUALITY AND CLINICAL METRICS TO REFLECT TECHNOLOGY PRE- AND POST-COVID

O'Reilly-Shah et al[2] reflect on the ethics and privacy challenges with data-sharing.[2] Demonstrating and measuring improvement are equally relevant to the successful implementation and sustainability of any technological platform. Creating a robust and consistent framework in these areas will ensure that the impact of technological advances on the quality, safety, and access to care are validly measured.

Certain types of technology, specifically, telehealth and telemedicine, have an assessment process recommended by national organizations, including the National Quality Forum (NQF), which could be extrapolated to measure the impact of other emerging technologies like predictive analytics and machine learning. The NQF has identified 3 factors most relevant to the adoption of technology: measuring its effect on quality outcomes, processes, and cost; selecting widely impactful quality measures; and using consistent definitions.[16]

The NQF also has defined essential categories for measuring telehealth as a means of care delivery, including access to care, financial impact to patients and their care providers, patient and clinician experience, and effectiveness of clinical and operational systems. Among these, the NQF suggested 6 priority areas: travel, timeliness of care, actionable information, impact of telehealth in providing evidence-based practices, patient empowerment, and care coordination. These NQF recommendations can serve as a guide in creating metrics for the impact of technology in anesthesiology and perioperative medicine.

Using the quality domain as a framework to monitor the outcomes, access, and consistency of

innovative technologies also has implications for how these modalities can be included in payment systems. For instance, the NQF has suggested incorporating telehealth and telemedicine into the Merit-Based Incentive Payment System (MIPS) with respect to providing expanded practice access and encouraging population health management. Each of the 9 MIPS improvement activity (IA) subcategories can be used to measure the impact of technology in anesthesiology and perioperative medicine (Table 2).

While the COVID-19 pandemic accelerated technological innovation and facilitated easing of existing regulations for clinicians and federal technological oversight, it does not absolve practitioners from thoughtful analysis of the impact of new technology on care delivery. We advocate using consistent quality and clinical outcome measures in evaluating any technological platform and suggest how these can be easily applied to anesthesiology and perioperative medicine. Establishing a uniform framework will ensure addressing the ethical and health equity implications of technology as we chart a new course after the initial COVID-19 surge.

Table 2. Technology Improvement Activities for Anesthesiology and Perioperative Medicine

IA Subcategory	Example
Expanded practice access	Expanded telehealth hours in preoperative anesthesia clinic
Population management	Use of QCDR to track population outcomes during pre- and postoperative consultation
Care coordination	Implementing care coordination and transitions of care planning in preoperative, postoperative, and postdischarge settings
Beneficiary engagement	Use of electronic patient portals for preoperative optimization and patient education
Patient safety and practice assessment	Use of risk assessment tools (eg, NSQIP Surgical Risk Calculator)
Participation in APM	Hospital-at-home model
Achieving health equity	Measuring access to virtual visits in preoperative and postdischarge settings for patients from different geographical locations
Emergency response and preparedness	COVID-19 preparation as crisis care situation and public health emergency
Integrated behavioral and mental health	Smoking cessation interventions in preoperative clinic

Abbreviations: APM, alternative payment model; COVID-19, Coronavirus Disease 2019; IA, improvement activity; NSQIP, National Surgical Quality Improvement Program; QCDR, Qualified Clinical Data Registry.

ADVANCING PERIOPERATIVE MEDICINE AND VALUE-BASED CARE THROUGH TECHNOLOGICAL INNOVATION

In the inevitable post-COVID pandemic era, what is the anesthesiologist's role in technology as our health care systems and other major stakeholders define the "new normal?" Is this our opportunity to take a legitimate seat at the table of state and national discussions on value-based care and population health management strategies using our understanding of the continuum of care from the preoperative phase through the postdischarge phase?

We will need to consider the optimal role of technology in addressing the currently accrued, and likely future ebbing and flowing "care debt" of deferred surgical treatment due to canceled elective procedures, as well as deferred medical conditions that worsen and require emergency procedural intervention.

Others have also suggested this window as a launching point for discussion on value-based care approaches in surgical and perioperative team-based settings.[13] Working collaboratively will incorporate all members of a multidisciplinary team, including surgeons, anesthesiologists, nurses, physical therapists, and others, to embrace care delivery models that promote high value and efficient clinical care pathways and empower patients and caregivers through their coproduction and increased use of patient-reported outcomes.

Future innovation of technological platforms will allow decentralized care delivery through virtual pre- and postoperative appointments and the growth of home-based care and rehabilitation. As anesthesiologists, we are uniquely positioned to add meaningful value to this discussion. We are not only able to monitor and treat continuously changing physiologic parameters but also to adapt to ever-evolving environments. These abilities contribute new dimensions to future care delivery models. Leveraging our specialty's strengths in technology, hemodynamic monitoring, and predictive analytics provides the platform to redesign and advance our profession and perioperative medicine after the initial COVID-19 surge and beyond. The tipping point has arrived, technology will certainly advance, and adoption is sure to generate discontent. It is our duty and calling to embrace these frontiers and opportunities in the name of both invention and progress.

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