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HOW THE FUTURE OF MINIMALLY INVASIVE SURGERY COULD REVOLUTIONIZE HEALTHCARE

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Minimally invasive surgery promised faster recoveries, less pain, less ‘collateral’ damage to healthy parts of the body and fewer complications, thus reducing costs and improving outcomes.

But in many cases, benefits haven’t been realized as quickly as promised, with a number of drawbacks limiting the effectiveness of minimally invasive surgery.

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One limitation is the control and precision surgeons have during the procedure. Due to the small size of the incision and remote manipulation tools, surgeons have much less room to operate, requiring additional training and experience to speed up surgery times and reduce complications.

Another limitation is imaging. In minimally invasive surgery, the anatomical information and tool placement is only visible via medical imaging, like fluoroscopy. However, fluoroscopy relies on contrast dyes and X-rays to create grainy, black and white, 2D images.

Fortunately, researchers around the world have been working on resolving these limitations.

In my opinion, there are three key technologies that will help us revolutionize minimally invasive surgery:

1. Robotic-assisted surgeries
2. Enhanced, real-time imaging
3. Predictive modeling and artificial intelligence (AI) using big data

To understand how and why these technologies will revolutionize healthcare, let's look at each to uncover the most exciting developments in each field.

Robotic-Assisted Surgery

The potential for robotic-assisted surgery was recognized nearly two decades ago. Of course, implementing robotics in the operating room takes a lot of work. Leading the field is Intuitive Surgical with its da Vinci robot, which originally gained U.S. Food and Drug Administration approval back in 2000.

Using a control panel and screen, surgeons can direct da Vinci's robotic arms, attached with surgical tools, to conduct a number of procedures. The main benefit of the system is its ability to offer enhanced control and precision.

In the future, robots will do the 'mechanical' setup for the surgery autonomously — correctly positioning the right tools in the patient's body. It will also be possible to use robotic surgery devices remotely from anywhere in the world. This could open up access to high-quality surgeries to millions of people.

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So far, the major downside of surgical robots has been cost. A single da Vinci robot costs about $2 million upfront, while a single surgery generally costs anywhere from $3,000 to $6,000 more than traditional laparoscopic surgery.

However, new challengers have been working to reduce cost. I expect these technologies to continue to develop and converge to create a robotics suite that will provide control and precision, automated setup and remote operations as cost-effectively as traditional surgeries.

Enhanced, Real-Time Imaging

The current imaging gold standard for minimally invasive surgery is fluoroscopy. The other option is to use tiny cameras mounted on the end of tube devices that can be inserted by hand, along with the surgical tools, in case the surgery is not inside a vessel full of blood.

Both these imaging solutions suffer from poor quality. The human eyes and brain haven't evolved to intuitively interpret these kinds of poor images. Not only can using them be incredibly tiring for the surgeon, it can increase the surgery length and lead to mistakes. What surgeons need is imaging that works with natural human perception.

Several companies have been working on improving surgical imaging to reduce or remove reliance on dyes and radiation, while producing a superior image quality.

Centerline Biomedical, a Cleveland Clinic spinoff, of which I am president, has developed the proprietary Intra-Operative Positioning System (IOPS), which uses mathematical algorithms and a safe electromagnetic field to provide 3D color visualization and real-time tracking of devices in minimally invasive vascular surgeries. IOPS uses graphics and augmented reality to provide a clear image for more intuitive operation. Surgeons can apply all their skills, intuition and experience to the patient, rather than dedicating time and attention to interpreting the image.

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Other imaging systems are focusing on different specific surgical regions or applications. Johnson & Johnson's CARTO System, for example, specializes in heart navigation, producing images that are revolutionizing treatment of arrythmias, while minimizing patient trauma.

ChemImage's Molecular Chemical Imaging (MCI) uses a combination of spectroscopy — the detection of specific matter based on electromagnetism — and digital imaging to help surgeons identify and remove tumorous tissue.

The Novorad AR headset helps surgeons to plan before operating, allowing them to appreciate the patient's anatomy by seeing it as an overlaid image in advance of the surgery.

As we improve signal processing and continue to develop new imaging technologies, other options for seeing into a patient will emerge. Images will become increasingly intuitive to use, while offering granular detail that we can currently only imagine.

Predictive Modeling and AI Using Big Data

In human beings, intuition is our brain's way of managing overwhelming amounts of data. The more experienced the surgeon, the greater their training and experience, and, therefore, the better their surgical intuition.

However, in the age of informatics, we can now collect, analyze and share that data, that experience, to help surgeons make better decisions in real time.

One of the biggest areas for data capture and analysis in hospitals is surgical workflows. Smooth workflows mean OR staff have what they need in the right place at the right time, leading to fewer errors and less wasted time. Efficient workflows also help improve communication between all staff members, even when they're from different teams, fostering an instinctive understanding of what to do, when.

Overall, a smooth workflow reduces the chance of complications, reduces the time spent under anesthesia and minimizes staff fatigue to make for a more alert and capable workforce.

For example, ExplORer Surgical uses tablets in the OR to create balanced workloads and offer learning from experience of previous cases. This approach could quickly develop optimal surgical workflows and refine them in real time, continuously providing the very best workflow management.

When it comes to surgery, data could also offer useful insights, particularly when formed into predictive models. New technology can, with a high degree of accuracy, predict what will happen if, for example, a surgeon inserts a blood vessel stent.

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When combined with AI, the applications for big data and predictive modeling become astounding. In the OR of the future, surgeons will be able to ask their AI assistant the most likely outcome of a particular action or procedure and get a highly accurate, real-time response.

The future looks particularly bright for surgeries right now. These technologies will, I expect, develop at incredible speeds and combine in novel ways not yet anticipated. The outcome will be surgery that is quick, efficient, relatively painless, and reduces complications and follow-up procedures. This will reduce costs and time, making minimally invasive surgery a more realistic option for the majority of people, averting the potential crisis faced by healthcare administrations.

ABOUT THE AUTHOR

Vinod K. Goel, Ph.D. is president of Centerline Biomedical, Inc. Centerline is developing next-generation imaging and precise real-time 3D navigation to empower physicians with solutions designed to improve outcomes, lower costs, simplify complex procedures, and reduce radiation exposure to patients, clinicians and caregivers in minimally invasive endovascular procedures. Founded in 2014 as a spinoff of Cleveland Clinic, Centerline is changing the way healthcare is delivered.

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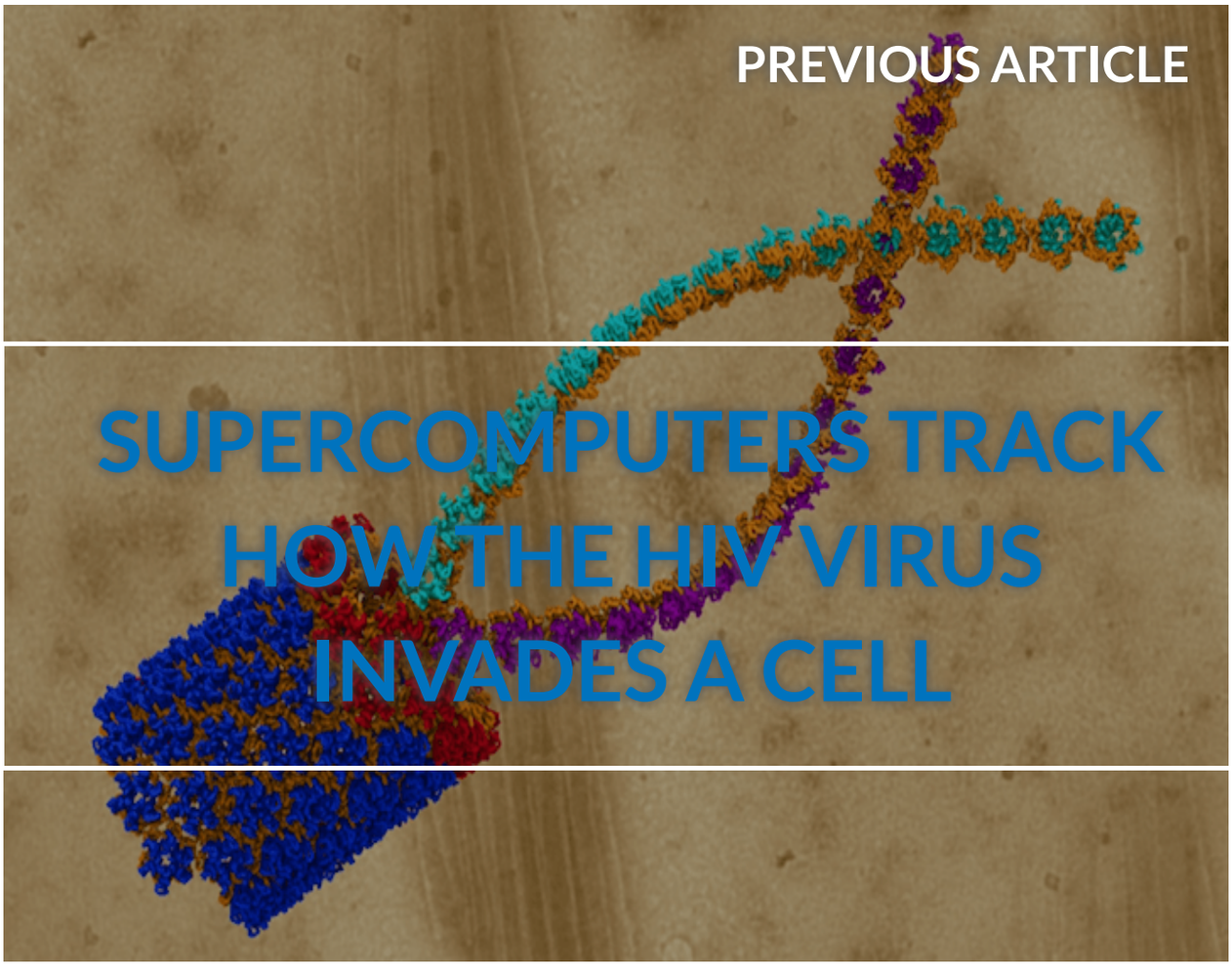

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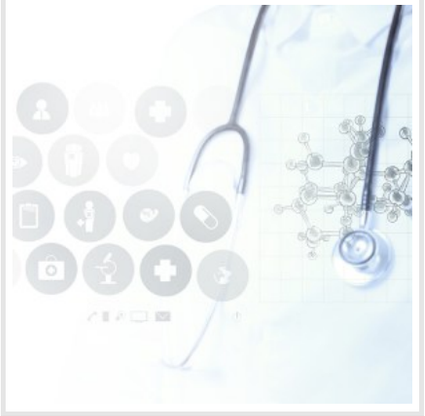

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