MECHANIZED MEDICINE

THE INTERSECTING ROLES OF HUMAN DOCTORS AND MEDICAL ROBOTICS

Already hard at work in hospitals around the world, medical robots are enabling surgeons to perform complex operations with much success. Infact, these surgical robots equip doctors with extraordinary precision, providing heightened visual aid, controlled micro-movements in and around sensitive tissue structures, and minimally invasive entry points. This reduces the risk of infection and healing time for patients, translating to less post-op care-associated costs for providers.
Other robots allow clinicians to work remotely, or enable supervision and outreach into distant or rural areas, or help provide basic home care tasks.

Poised to take the next leap, robotics are climbing a continuum of safer surgeries, earlier interventions, better patient outcomes, reduced costs, and global access to health care. And while we are far from a Jetsons-esque culture of carefree automation, in some ways the advent of widespread medical robotics is finally answering the promise of technology to improve the quality of human life.

We ask four noted experts for their perspectives on how the use of robotics in surgery is opening up a new era of medical innovation and how else can we harness technology to complement the skills of human doctors in the future. Turn the page to find out their solutions_

CHALLENGE QUESTION:

"The use of robotics in surgery is opening up a new era of medical innovation. How else can we harness technology to complement the skills of human doctors in the future? Find the solutions here_"

DOLLARS, CIRCUITS, AND SENSE

The initial cost outlay for a medical robot may seem at first prohibitive. Yet, as **Dr. Christopher Cheng**, Head and Senior Consultant to Singapore General Hospital's Department of Urology, points out, "so is most advanced technology in medicine. The cost of each procedure comes down with more procedures done per year, thus diluting the capital and maintenance cost." An important consideration, he says, is that "from the institution's standpoint, there is also the early adaptor benefit of staff retention, enhanced research potential and building of advanced technology reputation." However, he warns, this should be subject to careful oversight: "Patients may be attracted to inappropriate treatment. Ultimately it is up to the ethos of the institution and physicians to practice appropriate, patient-oriented medicine" he said. "Technology is neutral."

ACCELERATING CHANGE

The learning curve for robot-assisted surgery is reportedly shorter than traditional surgical techniques, though there is a valid concern that with the uptake of robotic techniques comes the scarcity of traditional surgical methods. However, **Dr. Thomas Lendvay**, Assistant Professor of Pediatric Urology at Seattle Children's Hospital, notes that virtual reality technology enables faster training because it is not dependent on the use of the robot itself. To this end he has developed a virtual reality curriculum in which trainees practice different tasks, exercising camera movements, clutching movements, instrument transferring of materials, and some needle and suturing work. Then, says Dr. Lendvay, "When subjects go from the simulator to the robot, they are much more comfortable learning the robot's movements."

Someday, Dr. Lendvay believes, "virtual reality training will be used for patient-specific simulations. Pre-operative imaging will recreate a 3D simulation of a patient's specific anatomy for practice performance before the actual live surgery, allowing the surgeon to become familiar with structural details like vasculature or tumor location."

MAPPING THE FUTURE

The use of virtual reality in surgical robotics is already proving helpful. But the possibilities don't end with training: in the future, the combination of pre-operative imaging and 3D modeling could be mapped in real-time to the patient, allowing the surgeon to see labels and marked areas of

important tissue structures overlaid on what is directly visualized by the robot's camera. Further, Dr. Lendvay envisions improvements to the sensors on the robotic instruments themselves, "such that we can get more information about the tissues as we're handling them." For example, biophotonics, light sensors that can determine tissue oxygenation and blood supply to the tissue as it is being grasped, would display to the surgeon in real-time, providing valuable statistics on how the procedure is affecting the patient on a moment-to-moment basis.

GAINING GROUND

Jacob Rosen, robotics expert and Associate Professor of Computer Engineering at the University of Santa Cruz, is working on one of the biggest challenges facing medical robotics: the human-machine interface. With his wearable "exoskeleton" robot prototype, he is developing its application for rehabilitation and physical therapy, particularly for stroke patients who typically experience one-sided loss of movement and for anyone recovering from surgery who needs to regain muscle strength and coordination. Rosen describes how, in conjunction with neuroscience's theories of symmetric movement, his exoskeleton "allows the patient's healthy side to tele-operate the non-healthy side."

This is accomplished through the use of surface electromyography (EMG), where electrodes placed on the healthy side of the patient's body transmit predications based on neuro-muscular impulses to the exoskeleton on the side damaged by stroke or injury and subsequent surgery. The exoskeleton then conducts exact, mirrored movements of the damaged side in concert with the healthy side. These exercises rely on the plasticity of the brain to simultaneously teach and relearn movement-based impulses. And the bonus is, as Rosen points out, "therapy that was once limited by the therapist's time, is now only constrained by the patient's ability to learn." And, as we're discovering, that potential is nearly endless.

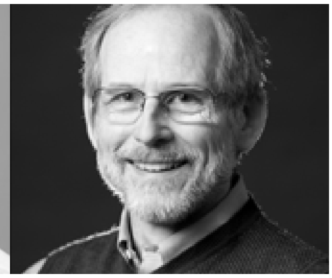
LIVING MACHINES

Generally when we think of robots, we picture machines of metal or plastic, wires and motors, running on electricity and complicated software. However, in medicine, another kind of robot entirely is emerging: a living machine, or biological robot, comprised of real cells or tissues which themselves carry out specified tasks via chemical or genetically coded instructions. Research partnerships like the Singapore-MIT Alliance for Research & Technology are focused on bridging the gaps between engineering and molecular cell biology. Future applications for this technology may include drug monitoring, reporting, and adjustments in the bloodstream, or identification and remediation of unhealthy bodily intruders such as cancer cells.

Will these "bio-bots" soon be taking over the OR? "It's probably more likely that biotechnologies will help make surgery obsolete, or at least unnecessary in many cases," says **Roger Kamm**, Singapore Research Professor of Biological and Mechanical Engineering at Massachusetts Institute of Technology. "'Smart' implants might know where to go, how to connect with the resident tissue, and what to do to treat the medical condition." Cells could be engineered to perform specific functions such as generating new tissue in an infarcted heart, or injected into the liver to reverse the destruction of fibrosis. "This may seem far-fetched," Kamm says, but in fact, "it may not be that far off."

singapore sessions

MEET THE SESSIONISTS



Dr. Christopher Cheng

Dr Christopher Cheng graduated from Singapore University in 1982 and obtained his post-graduate degree in Surgery FRCS in 1986, and FAMS (Urology) from the Academy of Medicine, Singapore in 1993. He obtained his Uro-oncology Fellowship after spending two years at the Mayo Clinic, USA from 1990 to 1992. He is the Chairman, Transplant Workgroup Committee, Singapore General Hospital and a member of the Transplant Advisory Committee at the Ministry of Health, Singapore. He is also the Chairman of the Robotic Minimally Invasive Surgery Steering Committee at SGH. Dr Cheng's clinical and research fields of interest include uro-oncology, renal transplantation (living-related and cadaveric) and minimally invasive surgery.

Dr. Thomas Lendvay

Dr. Lendvay is a graduate of the Temple University School of Medicine and completed his residency in urology at Emory University. He also completed a two-year pediatric urology fellowship at Seattle Children's Hospital. Dr. Lendvay is a University of Washington assistant professor of urology and is co-director of the Seattle Children's Robotic Surgery Center. He is particularly interested in robotic surgery and the incorporation of robotics into pediatric surgery, and recently received an award from the U.S. Army Medical Research and Material Command and Department of Defense to study the effect of a pre-operative warm-up on virtual reality surgical task proficiency.

Jacob Rosen, Ph.D

Jacob Rosen is an Associate Professor at the Department of Computer Engineering, University of California-Santa Cruz (UCSC). His research interests focus on medical robotics, biorobotics, human centered robotics, surgical robotics, wearable robotics, rehabilitation robotics, neural control, and human-machine interface.

Roger Kamm

Roger Kamm is the Singapore Research Professor of Biological and Mechanical Engineering at MIT. He has been a leader in bringing the fields of mechanics together with biology and chemistry by exploring the ways in which cells respond to mechanical force, and using microfluidics to explore cell-cell interactions. This cumulative work has led to over 180 refereed publications. Recognition for his contributions is reflected in Kamm's election to the Institute of Medicine and as Fellow to AIMBE, ASME, BMES, and the IFMBE. He is also the 2010 recipient of the ASME Lissner Medal for lifetime achievements.

WHAT ARE THE SINGAPORE SESSIONS?

Whether it's the economy or the environment, one thing is certain: The future of the world is inextricably linked to the future of business. More than ever, we need to find innovative solutions that can turn future business challenges into opportunities.

By bringing leading experts in diverse fields to the table, the Singapore Sessions explore the diverse solutions that are possible for any one given challenge. This offers unique insights into how we might answer some of tomorrow's challenges today. To see other Sessions that may interest you, or to be alerted to Singapore Sessions content as it comes online, subscribe today at SingaporeSessions.com