Director of McMaster's Centre for Minimal Access Surgery since 1999, Dr. Mehran Anvari has pioneered revolutionary technologies and such as telementoring and telerobotic surgery at McMaster and St. Joseph's and is recognized internationally as a minimal-access surgery expert

Rise of the Robots

A city once famed for brute metal muscle seems turned upside down these days

By Mike Pettapiece

Long seen as a manufacturing giant, particularly in the steel sector that gave the city its nickname, Hamilton is increasingly known for its smarts down at the body's minute molecular levels. The city has traded macro for micro as it stakes out territory in nanotechnology, nuclear medicine and the wonders of the human genome.

Now, add to this portfolio an ambitious project to create jobs and businesses with a made-in-Hamilton surgical robot. It would be brainy and precise, and operate in the body's tiniest spaces. If the plan succeeds – and the risks are as great as the rewards – the robots would be sold to clinics, hospitals and health care centres in Canada and abroad. They might ultimately be used on battlefields or even in space.

The robots would trade on the world-class reputation of Hamilton doctors, engineers and scientists and on the out-of-this-world brilliance of the company behind the telescoping Canadarm grappler, its robotic barrel flashing a maple leaf 300 kilometres above the earth.

The project also brings together two 'star' doctors: Mehran Anvari, president of the international Minimally Invasive Robotic Association, and David Williams, a former astronaut (twice in space).

"Canada is at the leading edge in space robotics with Canadarm and so on," says Dr. Anvari, a medical robotic expert and surgeon at St. Joseph's Healthcare. "We're now trying to translate that edge into the medical field."

Ottawa believes in the plan. The federal government has kicked in almost $15 million in long-term funding for the new Centre for Surgical Invention and Innovation (CSII). B.C.-based company MDA (MacDonald, Dettwiler and Associates) also believes. MDA is the company behind Canadarms 1 and 2.

Together, MDA and McMaster – sixth among Canadian universities in overall research income – are supplying another $15 million in funds and in-kind time, research and equipment.

Dr. Anvari, scientific director for the new centre, envisions lightweight and mobile systems

PHOTOGRAPHY BY JON EVANS

Seeing through an endoscopic camera and working via robotic arms, Dr. Anvari's expert hand, wrist and finger movements are communicated from a lab console to surgical instruments in a distant operating room

that could be adapted to a variety of health care uses. Ideally, they would be automated (that is, programmable) and would have real-time imaging guidance beyond existing magnetic resonance (MRI) resolution. They would be used both on-site and in telerobotic or distance surgery, wherein a skilled doctor operates at a console perhaps hundreds of kilometres from the actual surgery site, using dedicated high-speed video-communication links.

Ultimately, the plan is to run this program out of McMaster Innovation Park, just off Highway 403 in the city's west end. The park is to be a hothouse that spins out new jobs and companies.

Dr. Anvari has grand visions for his robot: "We will be able to work in nanometres of accuracy rather than millimetres," he enthuses. That's ridiculously microscopic: A nanometre is a billionth of a metre. To put it into perspective, a human hair might be 75,000 times wider than a nanometre.

Hamilton's robosurgeon would have exquisite navigation skills, with pressure-touch or sensing capability finer than that of a human hand. It would help doctors do major operations, such as heart procedures, and could assist in tricky work, such as pedicle screw drilling (in spinal fusions) or doing biopsies. It might also be a guiding hand in helping nuclear medicine imaging probes "see" early-stage diseases in the body.

There is a sort of rough blueprint for all this. For the past three or so years, Hamilton and MDA experts have worked on creating and honing IGAR, an Image-Guided Automated Robotic platform. The expertise behind IGAR will be applied to this next-generation system.

There's big money to be made from medical robots and robotic tools. By one estimate, well over 10 million robotic-assisted biopsies, surgeries and other procedures in the U.S. alone took place in 2008. Last year, the king of robots, the da Vinci system, did more than 200,000 major procedures, such as prostatectomies -- the so-called "killer app" for robots. Each da Vinci system, made by a California company, costs about $1.4 million US. And the global market is growing. A Massachusetts firm, WinterGreen Research, puts the worldwide arena for all robotically assisted

surgical systems at more than $13 billion US in four years. A less robust guess by BCC Research pegged the medical robotics and computer-assisted surgery market at $3.3 billion by that year.

But it's also a tough marketplace. Several countries have nationally funded robotic programs and there are scores of robotic companies out there. One of them, Engineering Services, draws on expertise at University of Toronto as it develops an MRI-guided robotic system for prostate cancer surgery. The Hospital for Sick Children has received $10 million from Ottawa for its KidsArm system, a robot for pediatric use.

Provincial governments aren't helpful. They've been reluctant to help cover costs of robot purchases and surgery. That's often left to hospitals' charitable foundations. There are also health regulatory hurdles – such as approvals from the Food and Drug Administration in the U.S. – to clear. But mostly, it's about time and money. Lots of money. Going from lab bench to assembly line can chew up years and enormous amounts of capital funding.

Take neuroArm, for example, a real Canadian success story. Recently bought by a Winnipeg company, neuroArm was conceived at the University of Calgary. The neurosurgery robot scored global headlines in 2008 with a medical first: a brain tumour operation on a 21-year-old mother. The MRI-aided neuroArm does both microsurgery and biopsy work.

NeuroArm was in development about nine years. By 2007, the then-private project had received $27 million in funding. Winnipeg-based publicly traded company IMRIS has just acquired the neuroArm company. IMRIS had worked with neuroArm to link MRI technology with the robot. Another partner was MD Robotics, a unit of the Canadarm company now embracing McMaster.

There's no doubt that McMaster is among Canadian universities pushing enterprise and innovation these days. But in general, commercial spinoffs from academic research have not been a strong point in Canada. A study last year by the Council of Canadian Academies noted, "the commercialization of university research has been, on the whole, disappointing." The report seemed to fault Canadian industry and its links with universities for lacking "an ecosystem," a demand-pull model to transfer technology out of the universities.

But it can be done. NeuroArm did it. RIM did it with the BlackBerry (even though that success is due perhaps more to hiring top-end graduates than to a specific university-company partnership). Closer to home, we have ProSensus Inc. A spinoff from the McMaster Advanced Control Consortium, the company designs process-control monitoring sensors for many industries, including pharmaceuticals and snack foods.

Dr. Williams, a director on the CSII board and head of Medical Robotics at St Joseph's Healthcare Hamilton, knows promising research has a best-before date: "The big question in the business world is time to market. How long is it going to take you to get a return on your investment?"

After all, government funding does end. Industry partners are needed to turn science into sales, to work with hospitals, health bodies, medical tool and supply firms, and financiers to put robotic systems on surgical floors.

To that end, Hamilton lined up some big hitters early on. Preliminary CSII partners include GE Medical, Johnson & Johnson (the Band-Aid people) and medical products company Stryker Canada, which is based in Hamilton. And, of course, there is the space-age partner in MDA Corp. The project can also draw on open-source technology and on other collaborators. One is the University of Western Ontario, with its own national robotics centre in London.

"It is unlikely that any one centre in Canada is going to bring the next-generation robotic surgical system to market," Christopher Schlachta, medical director of Western's robotic facility, known as CSTAR, said in an email exchange. "Such a development will be a collaboration of several centres, each bringing its own expertise to the project."

Western is particularly skilled at haptics – the tremor-free technology that provides a user with a computer-aided feedback sense of touch and pressure-sensitivity. That's important as the surgeon deals with body tissues or thin artery walls, commanding a set of robotic arms away from the operating table.

To succeed in business, all products must differentiate themselves. Hamilton hopes its next-generation system will be mobile, lightweight and versatile – and considerably less costly than the bulky da Vinci. Dr. Anvari thinks it is possible to build such a system for well under $1 million.

A more compact robot might also help countries that are struggling to reach the high-tech

Surgery, Evolved: Surgical Robots Make Doctors Better, Patients Safer

The use of medical robots is part of the evolution of laparoscopic surgery. Doctors who enter the body through tiny "keyhole" incisions know that minimally invasive surgery generally results in less pain, shorter hospital stays and faster returns to normal life. Such small-incision work has been around for about three decades. Only more recently have computer-assisted robots been used, working in something akin to master-slave roles with surgeons.

Some critics call them a triumph of marketing over good medicine. Many hospitals buy robots, the argument goes, in fear of losing their reputations as centres of high-tech excellence.

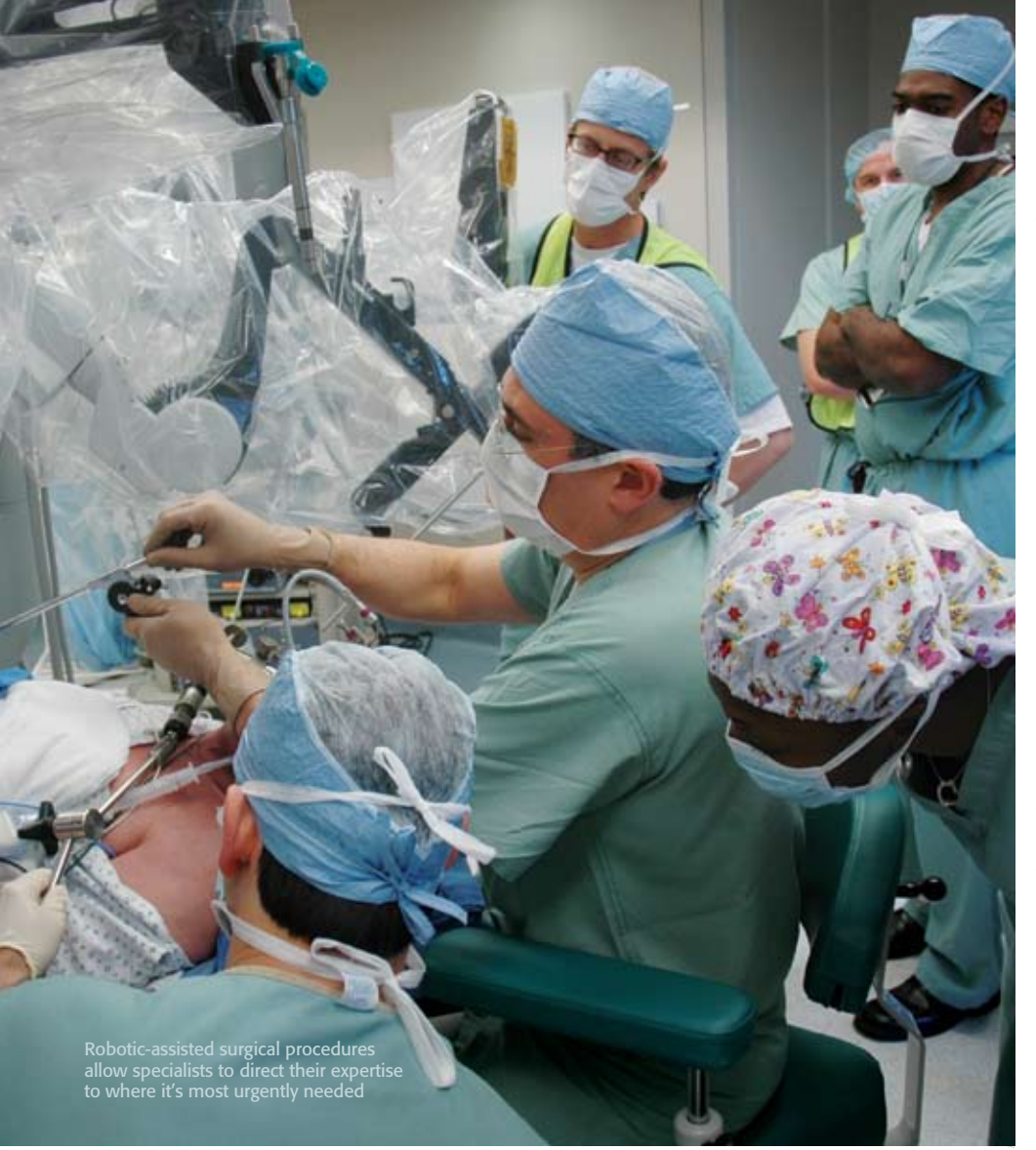
But what robots offer is more control and precision, the "stamina" for long surgeries and the tremor-free ability to see and operate in the body's ultra-tiny spaces. Robots make gifted surgical hands at control consoles even more masterful.

Medical robotic arms and systems have assisted in biopsies, radiotherapy, prostate and other cancer procedures, heart repairs, even organ transplants.

Robots help limit tissue trauma. Robotic-assisted cardiothoracic surgery, for example, allows surgeons to enter the heart cavity laterally, rather than slicing through the sternum. Doctors can also use natural orifices to enter the body for surgery.

Other efficiencies are just as notable. Least-harm minimally invasive surgery leads to less post-operative pain and infection complications, faster recovery times and shorter stays, which cuts hospital expenses. That's important in a country in which each patient-stay costs, on average, about $7,000, according to a 2008 Canadian Institute for Health Information study.

Professor of Surgery Dr. David Williams, Director of McMaster's Centre for Medical Robotics, and Dr. Dave Musson, Director of McMaster's Centre for Simulation-Based Learning collaborate on innovative surgical applications of the robotic vanguard



Robotic-assisted surgical procedures allow specialists to direct their expertise to where it's most urgently needed

frontier of surgical care. And a more modest system is a good fit for distance-surgery. Ideally, large nations (such as Canada) or undeveloped countries could provide first-class medical care to cities and towns located far away from urban clusters if smaller hospitals had access to a telerobotic system and mentor-doctors in large hospitals. The U.S. hasn't had a universal health care program until now, so robot makers stateside have had no incentive to make systems used for telesurgery. Only large hospitals could swing an in-house da Vinci platform.

One other possible application: If you can do it in a small town, you can do it in space, perhaps on a sick astronaut. Interestingly, McMaster offers a new course called Space Medicine and Physiology, one taught in part by Dr. Williams.

Dr. Anvari also believes a successful robot should be programmable, with surgeons inputting the parameters of an operation. This would be an advantage in touch-feedback sensing and in minor procedures where total hands-on surgeon control may not be needed. Programmable robots might also provide post-surgery clinical data to help improve future outcomes.

Doug Barber, chair of the new Hamilton robotic centre's board of directors, ponders the diagnosis. "I would say there isn't an academic robotic operation anywhere in Canada that has a real sense of who the customers are," he says. "Who buys this, who asks the potential end-users what they need and why they need it?"

Barber knows markets and innovation. A co-founder of semiconductor company Gennum Inc., he is an expert on commercialization and chaired the McMaster task force on ways to commercialize research.

Despite his clear-eyed caution, Barber expects that demand for a working robot will be "probably reasonably high." He also has an interesting take on his own question about customers. "The thing that gives me some real hope and expectation," he says, "is that he (Dr. Anvari) is a user, he is an end-customer. So (the project) has a huge leg up in that, if it doesn't work for him, it doesn't work." **HM**

Healing Hands: How High-Tech Hamilton Will Touch the World

Last March, the federal Networks of Centres of Excellence awarded $14.8 million to McMaster University for development and commercialization of novel surgical robotic systems.

McMaster's Centre for Surgical Invention and Innovation (CSII), based at St. Joseph's Healthcare Hamilton, intends to develop and commercialize a new class of robotic platforms for targeted, less-invasive surgical and medical interventions. The centre will be working with corporate partner MDA, the world leader in space robotics and developers of the famous Canadarm.

"Bridging the gap between research and commercialization is critical if we want to capture the true economic, social and health benefits of our work," said McMaster President Peter George. "This program allows for that to happen, creating a culture of innovation by bringing together those with the business know-how, the scientific excellence and the creative abilities to ensure this knowledge translation happens at an unprecedented pace."

Frontline researchers were equally enthusiastic.

"This investment by the federal government will enhance Canada's lead in the field of robotics and translate into new technology which will improve the quality and access to health care for all Canadians," said CSII director Dr. Mehran Anvari, who characterized it as a welcome investment that would creating high-tech jobs and foster the innovations of an emerging and evolving biotech industry.

Mag Iskander, president of MDA's Information Systems Group, also found the move encouraging, noting that the establishment of CSII "will extend Canada's leadership role in robotics to deliver world-class robotic technology that will benefit patients not only here in Hamilton, but around the world."

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