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From science fiction to "almost routine"

Heart surgery techniques and technologies once considered futuristic are now closer to reality

By Renee Sylvestre-Williams

Permanent artificial hearts, holographic image-guided surgery, "incisionless" operations and reviving dead hearts to use in transplant recipients may sound like the stuff of science fiction.

But they're all expected in the cardiac surgery of the future at the Peter Munk Cardiac Centre (PMCC). Supported by generous benefactors, a culture of innovation and a visionary team that spans disciplines and is dedicated to cutting-edge research, even the most futuristic cardiovascular therapies don't seem so far off.

"The field is changing dramatically," says Vivek Rao, 48, Chief of Cardiovascular Surgery at PMCC, who holds the Munk Chair in Advanced Cardiac Therapeutics and is Surgical Director of the centre's artificial heart program.

Dr. Rao, a recognized expert in end-stage heart disease who has helped build Canada's largest advanced heart failure program at PMCC, has already seen new technologies and techniques flourish through discoveries made there over the last two decades. "The future of cardiac surgery is changing in terms of what we traditionally do day-to-day."

Born in India, Dr. Rao immigrated to Canada at the age of three. He was drawn to medicine, having come from a long line of physicians, and was particularly inspired to pursue cardiac surgery by a character on the 1980s TV show *St. Elsewhere*, Dr. Mark Craig, who devoted himself to developing an artificial heart.

Back then, open heart surgery "was in its heyday," Dr. Rao recalls, with the prevalence of heart disease and "a flood of people who needed bypass surgery. There were few alternatives."

In the 1990s, a group of anti-cholesterol drugs called statins significantly lowered the progression of the disease, while percutaneous or minimally-invasive therapies, such as angioplasty and stenting, provided alternatives to opening up the chest. The new medications and techniques stabilized the amount of bypass surgery being performed, especially relative to the growing and aging population.

Today, many patients opt for angioplasty and stenting, Dr. Rao says; although, studies show that traditional open heart surgery is often superior in terms of outcomes. Surgeons are adapting by trying more minimally-invasive approaches, in some cases not using the heart-lung machine, for example, or making smaller incisions and enlisting robots to do coronary bypass surgery.

"Those innovations and technologies are still evolving," says Dr. Rao, who is a professor of surgery at the University of Toronto, noting that improvements in anaesthesia and surgery developed or validated at PMCC mean that complex cardiac procedures on high-risk patients once deemed "inoperable," such as those into their 80s, are now "almost routine."

Meanwhile, in valve surgery, catheter-based valve replacements have proven to be equal, if not better, in high-risk patients, he points out. Among the centre's research is a study to show whether the same is true in low-risk patients.

Diseases of the aorta, the biggest blood vessel in the body, are another major focus of PMCC, one of the largest aortic centres in the country. This is an example of its multidisciplinary approach. Someone who needs surgical treatment for his or her aorta will meet with a geneticist, an imaging specialist, a cardiologist and the aortic surgeon, among others, he says. "In one clinic visit, you're covered from head to toe."

The PMCC's multidisciplinary –

and pioneering – ethos extend to its nurses, dietitians, pharmacists, occupational therapists, physiotherapists and more, says Lindsay Love, 31, an Advanced Practice Nurse Educator in the Coronary Intensive Care Unit (CICU).

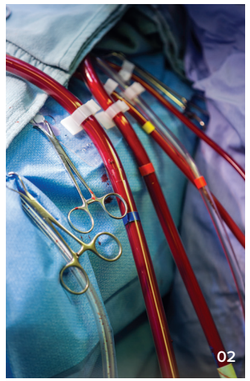
The emphasis on research and record of world "firsts" there fosters a spirit of curiosity among nurses and a "desire to keep learning," she says. Indeed, each year nurses from PMCC have been awarded prestigious fellowships under the Collaborative Academic Practice Innovation and Research Fellowship Program offered by the University Health Network (UHN). Ms. Love says that through the six-month pay-protected positions, nurses "are leading innovation themselves."

Dr. Rao focuses on heart failure, the inability of the heart to effectively pump blood throughout the body. Improving the survival and the quality of life of heart failure patients through new technologies, processes and strategies is a key focus of the new Ted Rogers Centre for Heart Research, he stresses. This can include artificial hearts, state-of-the-art medications, ways to monitor patients wirelessly and Web portals that provide education to them, as well as to families and health-care providers.

The PMCC's model of evaluating new technology through philanthropy is critical, says Dr. Rao, who launched the centre's artificial heart program in 2001, gathering data to show the Ontario Ministry of Health and Long-Term Care that outcomes with mechanical heart pumps were good enough to offer the technology to Ontarians. Limited government funding is now available for mechanical heart pumps in the transplant population.

Dr. Rao says there is still an "unmet need" for mechanical hearts in the many patients who are not transplant candidates. Today, philanthropic money is supporting four to five artificial heart transplants a year in these non-transplant patients to show whether outcomes justify financing the program.

"It's incumbent on centres like ours to go to our benefactors and launch an investigation into the efficacy and safety of a certain technique or procedure or device," he explains. The PMCC has done that on a number of occasions, for example, in groundbreaking research on minimally-invasive procedures to replace aortic valves. "There are also times when we evaluate technology, and we don't recommend going forward with it."



01 Dr. Vivek Rao (centre), cardiac surgeon, is an international expert in mechanical heart technology.

02 Tubes carrying blood to and from the heart-lung machine keep patients alive during bypass surgery.

03 One area of focus for cardiac surgeon, Dr. Mitesh Badiwala (immediate left), is reviving "dead" hearts so that they can be used for a future transplant.

There have been tremendous advances in artificial hearts from the first such device he introduced in 2001, called the HeartMate I, which was "huge" and designed to last only 18 months. Some nine different versions followed; Dr. Rao is now doing the first Canadian clinical trial of the HeartMate III.

The pumps, now implanted alongside the patient's own heart, are ever-smaller and more durable. But they're still powered by large external batteries, which have to be charged twice a day and cannot get wet, he says. "Clearly, what patients and surgeons want is to make everything implantable."

Making a heart that is not beating at all viable for transplant is the focus of cardiac surgeon Mitesh Badiwala, 37, one of PMCC's newest recruits. Dr. Badiwala, surgical director of the heart transplant program, says the use of such "ex-vivo" hearts would "increase the donor pool" beyond those who are brain-dead to include "donation after cardiac death." The hearts are removed, resuscitated, reanimated and then evaluated to see if they can be used to transplant into patients.

Dr. Badiwala thinks that someday ex-vivo and artificial hearts could be used temporarily while a patient's defective heart is removed, repaired and then sewn back in. "That's thinking into the future, but it might not be so far away."

In other advances, PMCC is launching a program in surgery for arrhythmia using a minimally-invasive approach where a videoscope can be inserted through a small hole in the side of the chest. This way, the "tracks" inside and outside of the heart that cause arrhythmia can be ablated or burned.

Advanced imaging is particularly helpful to surgeons using minimally-invasive techniques. Dr. Rao expects that soon with just the tiniest incision, a perfect life-sized or magnified image of the beating heart will be projected holographically outside of the body to guide surgeons using microscopic instruments inside.

He says it may also be possible to do surgery with no incision of any kind, akin to the way *Star Trek* chief medical officer Dr. Leonard McCoy used a focused beam of energy to sew off a vessel or cut out a lesion. "Certainly, the technology exists where you can focus a laser internally and not make any puncture on the skin, and if something's bleeding we can stop it from bleeding. We can probably also burn vessels or burn tracks that are causing arrhythmias."

He notes that lines in heart therapies are increasingly blurred. "If you're doing minimally- invasive surgery, are you an interventional cardiologist or are you a minimally-invasive heart surgeon?" he asks. "We're going to be trained in doing both, with teams that focus on heart failure, teams that focus on valve disease and teams that focus on aortic disease. That's how the patient gets the best care."

He's currently involved in clinical research, evaluating new surgical technologies and procedures, "so can we do the same thing, but do it better," and he has a basic science laboratory where PhD and master's students are trained to do molecular biology research, looking into the effect of transplants on the heart and blood vessels.

While transplantation remains "the well-accepted gold standard," he sees artificial hearts as the way of the future. "We're going to see a patient with heart failure, and we're going to say: 'Do you want to go on the waiting list for a transplant – which you may or may not get within the next year or two – or do you want to schedule your surgery for next Tuesday, and we'll put in an artificial heart, and you'll have a normal life expectancy?'"

Dr. Rao has won numerous awards for his dedication to finding answers in such areas. He says he would have never dreamed 30 years ago that he would be leading the Canadian research on each new generation of artificial hearts, as Dr. Mark Craig did on *St. Elsewhere*. "I am living the dream, so to speak."