Robotic surgery is used around the world to assist in abdominal and neck surgery and in New Zealand, it originally found a place in the treatment of prostate cancer. According to the Ministry of Health, prostate cancer is third-most common cause of cancer death in men after lung and bowel cancer.

Surgeons who adopt this computer-aided method require long training, an encyclopaedic knowledge of their speciality and many years of surgical experience. However, those who have swapped scalpels for joysticks report great satisfaction and results from their efforts.

There is a price tag. Patients must either have insured themselves against sickness or find around $30,000 to undergo this treatment. It’s a private hospital option, available only in Tauranga or Christchurch; no public hospital offers it yet.

So-called robotic surgery describes the use of a computer that enables non-invasive, laparoscopic surgery in which a surgeon precisely manipulates multiple probes, inserted through small incisions. Often, in abdominal surgery, it’s through belly-button to reduce trophy scars. The computer aids the precise movement of pincers that can clasp, stitch, staple, burn and cut their way through tissue to get at the seat of disease. Working in a 3D world, the robotic software is aware of where each of its arms is and which movements it can make safely.

The da Vinci Si IS3000 model, which New Zealand surgeons use, consists of three modules: the patient side cart, the surgeon console and the vision cart.

The surgeon console is the control side of the robot. This is where the surgeon sits and controls the movement of the instruments, the camera and any energy devices. The surgeon, armed with a sort of joystick affair in each hand, can virtually eliminate normal hand tremors and gain unprecedented dexterity to get to hard-to-reach places. He or she gets a front-row seat at 1080p (full high-definition) resolution through the camera: three of the robot’s arms have instruments and one has a controllable camera with four axes of movement. All commands are converted into fibre signals over a dual channel, which then go to the vision cart.

The commands are processed by the main controller in the core, through software algorithms, controlled via a three level (supervisor, middleman and kernel) software system. The kernel does all servo loop calculations and safety algorithms in what is considered real time at 750 micro seconds.

Commands are converted to fibre signals and transmitted over the fibre cable to the patient side cart. They are then converted back and routed to the correct remote arm controllers for the three patient side manipulators or the camera manipulator servo drive controls.

Each patient side manipulator has a servo encoder and a digital pot for each axis. This ensures the arms are moving correctly. The patient setup joints, which are not motorised, have dual digital pots on the axes to ensure the arms are located correctly. These double check every movement and generate an alarm if anything is incorrect.

The vision cart houses the core, which is the central processing unit (CPU). The CPU, as much at home as in an auto pilot on a passenger jet or the artificial intelligence for a peasant in a
Action shot of an operating room featuring the da Vinci Si Surgical System. Photo: © 2014 Intuitive Surgical Inc.

Opposite: The patient-side cart, where the patient is positioned during surgery. The cart includes multiple robotic arms that carry out the surgeon’s commands. Image: © 2014 Intuitive Surgical Inc.
game of “Age of Empires”, becomes a silent surgical guide, allowing manipulative movements that would be difficult and even impossible in some cases by the surgeon's hand alone. This precision and dexterity is needed, particularly in cases of prostate cancer, to reduce subsequent erectile and continence problems that have dogged traditional, open prostatic surgery.

In Christchurch, Mr Kevin Bax works as a consultant urologist with Urology Associates. He uses open surgery in the public hospital and a mixture of open and robotic for Urology Associates' private patients. He has become a strong advocate for the use of robotic aids, particularly in the problematic area of prostatic surgery.

“Prostate cancer treatment comes with downsides. It certainly comes with lots of risks associated with treatment. The robot is basically a new advancement to try to decrease some of the complications associated with treatment,” he says.

Mr Bax says robotic surgery comes with a third the complications that open surgery does. “Open surgery, in which the surgeon opens the body to expose the area to be worked on, comes with about a 12 per cent complication rate, while robotics has maybe a four per cent complication rate. As fewer complications reduce the time spent recuperating in hospital, in my opinion it is more cost-effective to be used in public hospitals than open surgery, despite its higher initial cost.

“It’s got the same cancer cure but with decreased complications and a better functional outcome.”

After 12 months, Mr Bax says those who have undergone prostatic surgery – both open and robotic laparoscopic – have recovered to about the same level, though those treated with robotics reached that level many months earlier.

To those who point to equal recovery status after a year and ask what the difference is, Mr Bax says, “If you can spend 12 months in jail or one month in jail, and after 12 months you’re both equal again, which would you rather have?”

An American company called Intuitive Surgery makes the surgical computers. As with many American technical developments, the da Vinci model began life in the late 1980s as an army project. On this occasion it was looking to improve remotely-performed battlefield surgery.

The United States Food and Drug Administration approved the system for general laparoscopic surgery in 2000. It has since approved it for application in thoracic, cardiac, urologic, gynaecologic, paediatric and ear and throat surgery.

Is it safe, though? A quick Google websites in the United States offering 

### Prostate Cancer: Facts, risks and symptoms

<table>
<thead>
<tr>
<th>Function</th>
<th>What is prostate cancer?</th>
<th>What are the risk factors?</th>
<th>What are possible symptoms?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Gland producing fluid that protects and enriches sperm</td>
<td>• Prostate cancer occurs when some of the cells in the prostate reproduce far more rapidly than normal, resulting in a tumour</td>
<td>• Gender: prostate cancer only affects men, as women do not have a prostate gland</td>
<td>Note: the majority of prostate cancers have no symptoms, and it is really only advanced cancers that have spread throughout the prostate (and beyond) that cause urinary symptoms such as:</td>
</tr>
<tr>
<td>Location</td>
<td>• If left untreated, prostate cancer cells may eventually spread from the prostate and invade distant parts of the body, particularly the lymph nodes and bones, producing secondary tumours in a process known as metastasis</td>
<td>• Age: the older a man, the more likely he is to be diagnosed with prostate cancer</td>
<td>• Urinary issues (slow flow, hesitancy, frequency, urgency)</td>
</tr>
<tr>
<td>• Immediately below the bladder, in front of the bowels</td>
<td>• One of the most worrying aspects of the disease is that most prostate cancers develop without men experiencing any symptoms in the early stages.</td>
<td>• Family History: a man with a father or brother who developed prostate cancer before 60 is twice as likely to develop the cancer</td>
<td>• Blood in the urine or semen</td>
</tr>
<tr>
<td>• The prostate is doughnut shaped and surrounds the urethra, the tube that carries urine from the bladder out through the penis</td>
<td></td>
<td>• Reduced ability to get an erection</td>
<td>• Painful ejaculation.</td>
</tr>
<tr>
<td>• In younger men the prostate is about the size of a walnut</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The nerves that control erections surround the prostate.</td>
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</tr>
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</table>

If you have any concerns or are experiencing any of the symptoms above it is important to contact your doctor.
Note: These symptoms are also common to many conditions, not just prostate cancer.
to take up the cases of former patients who believe they’ve been harmed, not healed in computer-assisted, robotic surgery. The sales pitches on the lawyers’ sites are all earnestly quoting this or that specialist and claiming around 1,000 instances of medical mishap in approximately 450,000 robotic procedures using the da Vinci equipment.

Mr Bax blames the litigious pursuits on the United States’ system of private health care that lacks the public health system’s dominance in other countries. He says a surgeon can buy or lease a model and set up shop offering robotic surgery, without being properly trained. “No one checks,” he says. “If you don’t say you can do it patients will just go down the road. You therefore advertise to say ‘I do the robot, it’s wonderful, come and see me.”

Mr Bax likens using the machine effectively to learning how to use a mechanical digger (which, he says he driven and they’re “damned difficult”). “If you don’t know how to drive a digger it’s easier to dig with a bucket and spade. But if you know how to use a digger you can dig better than a thousand people with buckets and spades. This [robotic] machine’s exactly the same: if you know how to use it it’s wonderful but if not you can have more complications than with open surgery.”

The United States, he says, has had more than its fair share of complications. Surgeons who may have had only a fortnight’s training have defensively blamed the machine, which takes at least a year or two of training to become competent in its use — that’s at least 150 cases under supervision.

“This is a potentially dangerous machine if you don’t know how to work it,” he says.

A common claim used by United States lawyers is that the current that flows to the da Vinci’s pincers, which it uses to cut and cauterise, may arc onto flesh and burn the patient’s delicate vessels or nerves. Again, Mr Bax is adamant that that’s evidence of poor training. He says in his five years’ experience of robotics he hasn’t caused a burn.

Were he to need an operation himself, Mr Bax says he would certainly choose a surgeon who used robotics but — and here’s an inside tip from someone who now trains fellow surgeons in robotics — he says choose your surgeon well.

Despite the new toys, Mr Bax says a machine can’t substitute for the surgeon’s medical knowledge and skill at manipulating the robotic aids.

“It’s been proven that if you want a better outcome on the robot, choosing your surgeon is paramount. There is a lot of American data to say that if you want erections afterwards you need to choose a surgeon who has done a lot of robotic surgery and has good outcomes.”
He says his cautionary message is one built on observation and experience.

Even potentially great surgeons need a training paddock. Rather than being let loose on patients, the da Vinci simulator gains surgeons initial familiarity with the multiple arms and grips that combine to enter the human body and cut and repair by presenting exercises to improve dexterity and deftness. After that, they need extended training on live patients under the supervision of someone who has done it all many times before. In this respect, a dual surgeon console option is helpful, as it allows for two surgeons to control the robot: this is a great teaching aid for experienced surgeons to help newer ones.

Mr Bax’s own surgical training began at Greymouth and Christchurch. Then, under an Australasian urology training scheme he found himself in Adelaide at the only public hospital that performed robotics surgeries. He completed a year there during which time he found his mentor in the form of surgeon, Peter Sutherland. By the time Mr Bax met him, Mr Sutherland had already performed more than 600 robotic operations.

With his training up, he went to England for a further two years’ training in Europe’s busiest robotic centre in Bristol, until Urology Associates lured him back to Christchurch.

“IF SOMETHING GOES OUT OF SPECIFICATION – SAY FOR EXAMPLE THE SURGEON MOVES HIS HAND AND IT’S NOT WITHIN THE TOLERANCE SPECIFIED, IT WILL GENERATE AN ALARM.”

Mr Bax says he’s one of only two or three surgeons in New Zealand whose initial training has been in robotics, rather than as open surgeons who have learnt a new skill. He splits his working time fairly evenly between open surgery and robotics, the open being mostly for public patients. He estimates he has performed between 600 and 700 robotic operations and his skill level rises the more he operates. It doesn’t seem to be stretching an analogy too far to say the mechanical skill is similar to playing a computer game.

“It’s just like the best kind of computer game. I’ve 3D vision, 1080p, 10 times’ magnification. My [robotic] vision is superb - much better than with my eyes.” He says he can also move the wands much better than with his hands alone. The ratio of his scale of movement to the robotic instruments is one-to-four, so he can eliminate tremors and be extremely precise in what he can do. It’s adapting to this artificial, 3D, hand-eye co-ordination that takes the time.

A frequently asked question is “how do the surgeons know the robot is operating properly?” The answer is simple: there is an engineering monitor with the system.

When the robotic contraption lights up, support engineers in Japan and the United States see that it’s working and monitor it to ensure it stays inside its tolerances. They know what the machines are up to and how the surgeon is manipulating them. From a distance, they monitor the 25-or-so machines presently working in Australasia.

Brian Reader, an engineer with Device Technologies is based in Auckland. His team services the Tauranga and Christchurch installations.

Mr Reader says there are many components for each machine. Even a fan not spinning to speed will be noted and an alert sent to the international monitors who, in turn, alert field engineers. The systems have a servo loop of 750 micro seconds, so fast it is considered instantaneous. The loop is responsible for executing multiple inputs and multiple outputs.

“If something goes out of specification – say for example the surgeon
moves his hand and it’s not within the tolerance specified, it will generate an alarm,” he says.

A member of Mr Reader’s team will visit and replace such equipment. They can also reboot reluctant CPUs. Mr Reader isn’t talking about an equivalent of Windows’ “blue screen of death”. In practice he says, faults are apparent when the machine boots and none has ever had an irrecoverable fault in Australasia during an operation.

For each arm that the surgeon manipulates, there’s a servo board each with eight individual servo drivers. This combination took a computer box of about half a cubic metre in the first model 12 years ago, but in common with the “faster, smaller, better” mantra that drives computing, Mr Reader says more recent models are the size of a packet of washing soap powder.

As the models advance and reduce in size, Mr Reader says what once took multiple and heavy cables draped over the operating room floor to drive the arms is now achieved by a 10-millimetre, slim, single fibre-optic cable. Both New Zealand’s models are third-generation, while a fourth-generation model has recently been approved for use in Australia.

Despite the advancing technology and marketing hype, we are still many years from true robotic surgery, in which a machine would nudge a surgeon aside and take over. That status may have arrived with Google’s smart car supplanting a driver - but a true surgeon’s skill remains in his or her own hands and at the heart of robotic technology for the foreseeable future.