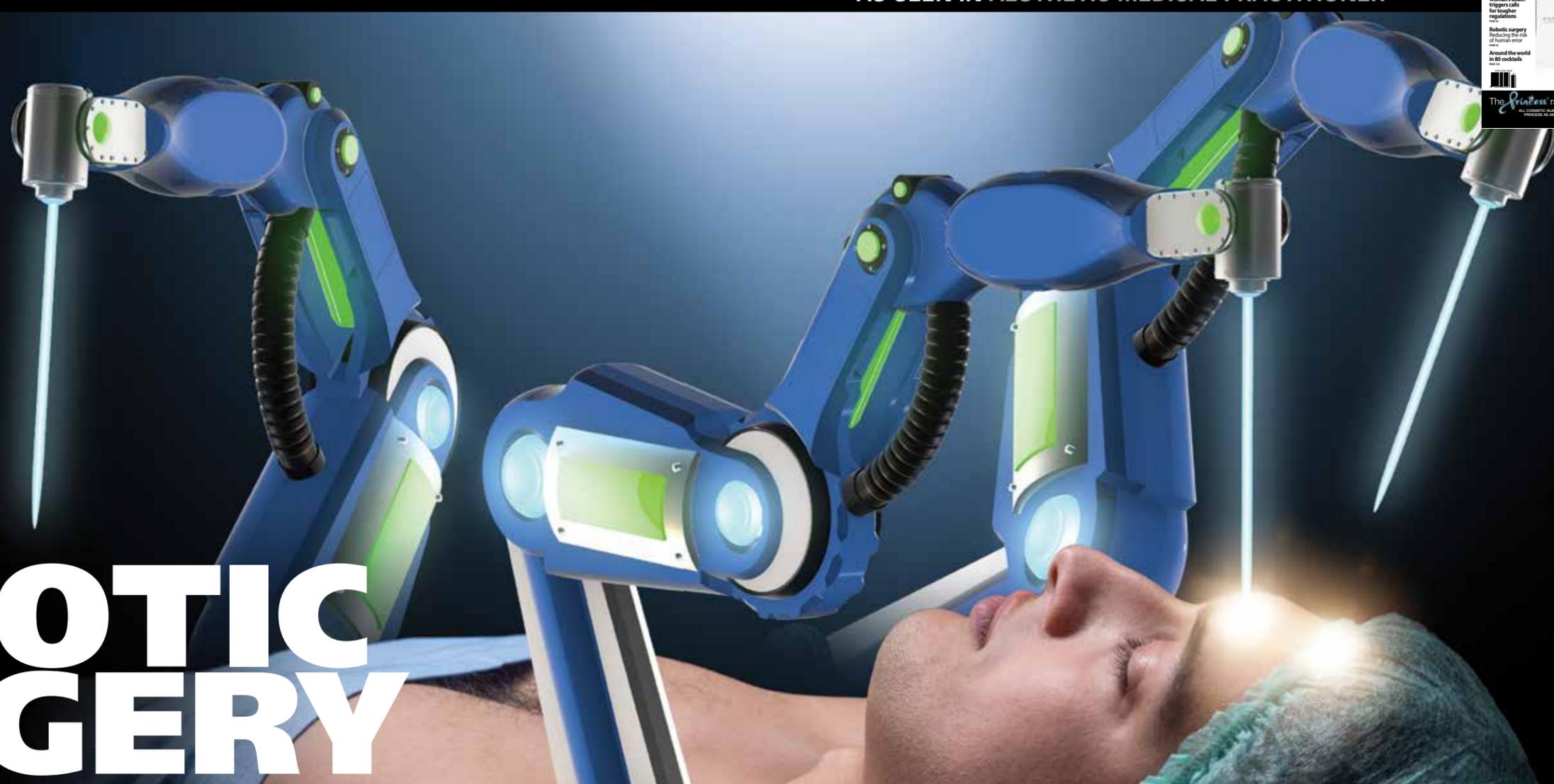




THE RISE OF ROBOTIC SURGERY



A TIDAL WAVE OF REVOLUTIONARY ROBOTIC TECHNOLOGIES IS IMMINENT – AIMING TO DELIVER SURGERY THAT IS MORE EFFECTIVE, LESS INVASIVE AND EASIER ON BOTH SURGEONS AND PATIENTS. WORDS BY DAVID HICKIE

Within five years, one in three US surgeries – more than double current levels – is 'expected to be performed with robotic systems, with surgeons sitting at computer consoles guiding mechanical arms,' reports leading American business magazine Fortune.

Similarly an RBC Capital Markets survey found US surgeons expect about 35% of operations will involve robots in five years, up from 15% today.

To date the field of 'minimally invasive robotic-assisted surgery' has been dominated by US Nasdaq-listed pioneer Intuitive Surgical. It has more than 4,000 of its da Vinci Surgical System machines in hospitals worldwide and boasts on its website that 'every 60 seconds, somewhere in the world, a surgeon uses a da Vinci Surgical System to bring a minimally invasive surgical option to a patient'.

Highlighting its rapid expansion, Intuitive Surgical reported in its July 2017 quarterly financial market update that 'worldwide da Vinci procedures grew approximately 16% compared with the second quarter of 2016' (driven primarily by growth in US general surgery procedures and worldwide urologic procedures) and the company 'shipped 28% more da Vinci Surgical Systems compared with the second quarter of 2016'.

Foreshadowing the ensuing tidal wave of revolutionary robotic surgical technologies this potential market has attracted, noted Fortune, 'the anticipated future is attracting deep-pocketed rivals', including Medtronic, TransEnterix, Canada's Titan Medical and a start-up (Verb Surgical) backed by Johnson & Johnson and Google. J&J, which hopes to be second to market with a product from Verb, has

publicly declared that it sees robotics as 'a multibillion-dollar market opportunity'.

And a report from WinterGreen Research projects the worldwide market for abdominal surgical robots (the category consisting of the da Vinci and its competitors) will grow from US\$2.2 billion in 2014 to US\$10.5 billion in 2021.

Company executives and surgeons told Reuters that 'developers of the next wave aim to make the robots less expensive, more nimble and capable of performing more types of procedures'. And Fortune highlighted the worldwide enthusiasm for the future of robotic surgery, emphasising: 'Companies developing new robots also plan to expand their use in India, China and other emerging markets.'

Although surgical robots cost an average of US\$1.5 million and entail on-going maintenance expenses,

'still most top US hospitals for cancer treatment, urology, gynaecology and gastroenterology have made the investment' summed up Fortune. Importantly the robots 'are featured prominently in hospital marketing campaigns aimed at attracting patients, and new doctors are routinely trained in their use.'

Intuitive Surgical's own data confirms surgical robots are used in hernia repair, bariatric surgery, hysterectomies and 'the vast majority of prostate removals in the United States'.

While many doctors report robot-assisted surgery can both reduce their own fatigue and assist them attaining greater precision, some argue the process can take more of the surgeon's time than traditional procedures, reducing the number of operations a doctor can perform.

Dr Helmuth Billy, an early adopter of

FEATURE

WE ALREADY TRUST ROBOT SURGEONS

IEEE Spectrum magazine noted that 'smart surgical systems already make decisions and carry out independent actions in a number of operations'.

SPINE

The guidance robot from Mazor Robotics uses the patient's CT scans to position a frame for surgeons' tools, giving them 1.5mm accuracy.

HAIR

In hair-graft surgeries, Restoration Robotics' system identifies hair follicles for harvesting, cuts them out and makes tiny incisions for the transplants.

EYE

In Lasik vision correction surgery, robotic systems from a variety of companies plan how to reshape patients' corneas, then fire laser pulses while correcting for eye movement.

HIP & KNEE

In joint-replacement surgeries, a robot from Think Surgical cuts through bone at precise angles to give the artificial knee the best possible alignment and stability.

CANCER TUMOURS

The robotic radiosurgery system from Accuray circles the patient, correcting for patient movement while delivering targeted beams of high-dose radiation to the tumour.

Intuitive's da Vinci system 15 years ago, told Fortune that equipping its arms with instruments slowed him down, explaining: 'I like to do five operations a day. If I have to constantly dock and undock da Vinci, it becomes cumbersome.' (The da Vinci Surgical System involves 3 components: a patient site robotic cart with 3 or 4 arms; a high definition 3D vision system; and a console where the surgeon sits to operate the robotic arms.)

And Dr Dmitry Oleynikov, who heads a robotics task force for the Society of American Gastrointestinal and Endoscopic Surgeons, told the magazine that, to gain an edge, new robots 'will need to outperform laparoscopic surgery'.

Several surgeons told Reuters they want the new robots to 'provide a way to feel the body's tissue remotely (called haptic sensing) and better camera image quality'.

New systems will also need to be 'priced low enough to entice hospitals and outpatient surgical centres that have not yet invested in a da Vinci' summed up Fortune's report, adding: 'Developers say they are paying attention.' Hence Verb Surgical (the J&J-Google venture) which is investing about US\$250 million in its project, declared 'creating a faster and easier-to-use system is a priority'.

Verb Chief Executive Scott Huennekens also envisions a system that is 'always there, always on', enabling the surgeon to use the robot for parts of a procedure as needed.

Intuitive said it too is looking to improve technology at a reasonable cost, but newcomers will face the same challenges. Intuitive CEO Gary Guthart emphasised: 'As competitors come in, they are going to have to work within that same framework.'

Meanwhile leading medical device maker Medtronic has announced it expects to launch its surgical robot before mid-2018 and will start in India.

Most recently the September 2017 edition of JPRAS (the journal of the British Association of Plastic, Reconstructive and Aesthetic Surgeons) has published a review of 'The Use of Robotics In Plastic And Reconstructive Surgery' which aims to 'study the feasibility, procedural approaches, outcomes and complications of robot-assisted plastic and reconstructive surgery in patients and models'.

The review noted that 'the rise in robotic-assisted surgery (RAS) results from a combination of patient and surgeon demand for minimally invasive procedures, and the continuous advances in computing power and robotic engineering'. And since a number of different robotic systems have gained US Federal Drug Agency approval for a range of thoracic, abdominal and pelvic surgical procedures, RAS has become commonplace in urological, gynaecological, vascular, cardiothoracic and general surgery.

The JPRAS review concluded 'robot-assisted plastic and reconstructive surgery provides clinical outcomes comparable to conventional techniques. Advantages include reported improved cosmesis, functional outcomes and greater surgeon comfort. Disadvantages included longer operating and set-up times, a learning curve, breaking of micro-needles, high monetary costs and authors consistently recommended improved end-effectors. All authors were optimistic about the use of robotics in plastic and reconstructive surgery.'



WOULD YOU TRUST A ROBOT SURGEON TO OPERATE ON YOU?

With that intriguing question as the headline, IEEE Spectrum (international magazine of the New York-based Institute of Electrical and Electronics Engineers, the world's largest technical professional organisation) noted that 'precise and dextrous surgical robots may take over the operating room'.

The magazine described watching surgeon Michael Stifelman (who has done several thousand robot-assisted surgeries as director of NYU Langone's Robotic Surgery Center) operating inside a patient's abdomen: he 'carefully guides two robotic arms to tie knots in a piece of thread. He manipulates a third arm to drive a suturing needle through the fleshy mass of the patient's kidney, stitching together the hole where a tumor used to be. The final arm holds the endoscope that streams visuals to Stifelman's display screens. Each arm enters

the body through a tiny incision about 5mm wide.

'To watch this tricky procedure is to marvel at what can be achieved when robot and human work in tandem. Stifelman controls the robotic arms from a console. If he swivels his wrist and pinches his fingers closed, the instruments inside the patient's body perform the same exact motions on a much smaller scale.'

'The robot is one with me,' Stifelman explained, as his mechanised appendages pulled tight another knot.

However Spectrum also reported that some roboticists, 'watching this dexterous performance, would see not a modern marvel but instead wasted potential'. They argue Stifelman is a highly trained expert with valuable skills and judgment — yet he's spending his precious time suturing, 'just tidying up after the

main surgery'. Predicting the future, they advocate 'if the robot could handle this tedious task on its own, the surgeon would be freed up for more important work'.

All sides of this debate agree that today's surgical robots extend the surgeon's capacities: they filter out hand tremors and allow manoeuvres which even the best surgeon couldn't pull off with laparoscopic surgery's typical long-handled tools (sometimes dismissively called 'chopsticks'). But at the end of the day, the robot is just a fancier tool under direct human control.

Dennis Fowler, executive vice president of surgical robotics company Titan Medical, is among those who think medicine 'will be better served if the robots become autonomous agents that make decisions and independently carry out their assigned tasks.

'This is a technological



ROBOTIC HAIR TRANSPLANT

In Australia, Dr Russell Knudsen has been using the ARTAS Robotic Hair Transplant System for the last 3 years. He describes it as a labour saving device that accurately harvest grafts via punch technique from the back of the scalp – a procedure usually performed by the surgeon and his surgical assistants.

The Knudsen Clinic in Sydney is the first hair transplant clinic in the Southern Hemisphere to utilise the ARTAS Robotic Hair Transplant System. According to Dr Knudsen, using the system results in consistent production of accurately cut grafts and allows larger sessions of Follicular Unit Extraction (FUE) surgery with minimal physical strain to the surgeon.

The ARTAS system uses sophisticated imaging technology, precision robotics, and intelligent algorithms to select only the best follicular units for extraction with low transection rate (less damage to hair follicles) and an increased chance of survival rate FUE grafts.

He reports his patients are very happy to use advanced technology for FUE harvesting and understand the benefits to both them and the surgeon.

intervention to add reliability and reduce errors of human fallibility,' commented Fowler (who worked as a surgeon himself for 32 years).

Spectrum summed up: 'Giving robots such a job promotion isn't particularly far-fetched; much of the required technology is being rapidly developed in academic and industrial labs. Working primarily with rubbery mock-ups of human tissue, experimental robots have sutured, cleaned wounds and cut out tumours. Some trials pitted robotic systems against humans and found the robots to be more precise and efficient.' For example in 2016 a robotic system in a Washington hospital stitched up real tissue taken from a pig's small intestine and, when researchers 'compared the performance of the autonomous bot and a human surgeon on the same suturing task', they found the bot's stitches 'were more uniform and made a tighter seal'.

While these systems are nowhere near ready for use on human patients, they may represent the future of surgery.

Hutan Ashrafian, a bariatric surgeon and lecturer at London's Imperial College who often writes about the potential for artificial intelligence in health care, considers automated surgical bots inevitable. In the foreseeable future, Ashrafian expects surgical robots to handle simple tasks at a surgeon's command, noting: 'Our goal is to improve patient outcome. If using a robot means saving lives and lowering risks, then it's incumbent on us to apply these devices.'

Looking further ahead, he predicts it's entirely possible that medicine will eventually employ next-level

surgical robots which have enough decision-making power to be considered artificially intelligent. Not only could such machines handle routine tasks, they could take over entire operations.

Ashrafian agreed that prospect may seem unlikely now, but the path of technical innovation may lead us there naturally. He summed up; 'It's step-by-step, and each one doesn't seem big. But a surgeon from 50 years ago wouldn't recognise my operating room. And 50 years from now, I expect it will be a different world of surgery.'

DEBATE OVER COSTS AND OPERATING TIME

In February 2017 the US Journal Of Urology published a report on the 'Rise of Robotic Surgery in the New Millennium'.

It noted: 'The years since the turn of the millennium have seen unprecedented infiltration of technology into daily life. In urology this change has been punctuated with the widespread adoption of robot-assisted surgery.'

The report confirmed 'the robot-assisted approach has become the dominant mode of surgical removal of the prostate'. It reflected how in 2000, before the development of robotic prostatectomy, Intuitive Surgical (manufacturer of the da Vinci system) 'was struggling with 18 systems worldwide, largely unused. By 2016 there were more than 3,700 da Vinci systems worldwide and more than 3 million operations performed.'

The journal declared urologists

'were the true pioneers, the barbarians at the gates of oncology, but gynaecologists followed soon after and general surgeons are heading there. Overall, the adoption of robotic surgery rivals the dissemination of many of the most common technologies in widespread use.'

However the report also highlighted a major current dilemma: 'The fairy tale rise of robot-assisted surgery has been inextricably intertwined with the ugliness of financial reality. The field has been dominated by a single manufacturer, which controls marketing and sales. Thus, costs remain high. Now more than ever, there is a strong demand for improving value in health care.'

'As in many other areas, large disparities in cost exist among surgeons and hospitals. At our own institutions inter-surgeon variation for something as easily measured as operating time can cost up to US\$5,000 a patient, which has led to many attempts to quantify the value of robot-assisted surgery.'

'Randomised controlled trials provide the highest quality data about the relative value of different therapies, but the costs of such trials are high and they are less easily generalisable for surgical procedures than for pharmacological therapies.'

The journal summed up: 'For sceptics, the early days of robotic surgery provide an example of the evils of uncontrolled marketing. For the faithful, these innovative times show how multi-disciplinary discussion, development of centres of excellence, peer evaluation with video crowd-sourcing, collaborative quality initiatives and,

WHY ROBOTS CAN BE BETTER SURGEONS

When Californian surgical oncologist Hormuz Irani was first approached to participate in a robotic-surgery training program, he resisted.

He'd been performing laparoscopic surgery since 1995 and had heard the da Vinci robot was bulky, expensive and time-consuming. But he told Fortune magazine that when he actually started using what he now refers to as the 'workhorse,' he 'saw the future of surgery'.

He explained the optics were clearer. Tremors from his hand vanished because the robot moved in a fluid motion. Smaller incisions left his patients with less pain and shorter healing times. The

arms of the robot swivelled 360 degrees, allowing it to do things the human wrist cannot – sew backward, for example, or sew underneath tissue.

Irani summed up: 'And it's ergonomic, so you're not hunched over a patient. That's definitely a big plus because we all end up with back, neck and wrist issues.'

The da Vinci Surgery System was initially approved by the US FDA in 2000 and, noting many more technological advancements have been made since then, Irani sees no sign of that progress slowing. And unlike before, he's looking forward to it, declaring: 'A robot could be that much more advantageous to use in the future. Better, lighter, cheaper.'

above all, listening to the patient can give real-time feedback and allow for continuous improvement when randomised controlled trials are impractical.

'These approaches have already been adopted by programs such as MUSIC (Michigan Urological Surgery Improvement Collaborative). Such initiatives show how surgeons can come together for quality improvement and adaptation in a rapidly changing world, skills that will become ever more important with growing demands to account for surgical quality and value in urology and other surgical fields.' **AMP**

‘ONE IN THREE US SURGERIES – MORE THAN DOUBLE CURRENT LEVELS – IS EXPECTED TO BE PERFORMED WITH ROBOTIC SYSTEMS WITHIN FIVE YEARS.’