Editorial

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The future of robotics

In the 1980s minimally invasive surgical techniques were booming across many disciplines, cutting postoperative recovery time by reducing postoperative pain, hospital length of stay and need for blood transfusion. Expansion, however, was limited by the complexity of surgery that could be achieved with the technical limitations that laparoscopic instruments present. Robotic technology, initially developed by defense organisations for remote operating, offers solutions to these limitations including 3-dimensional (3D) view of the operating field, filtering of physiological tremor, and articulate arms allowing greater precision and control. The opportunity to combine robotic technology with laparoscopic surgery was seized by commercial platforms, and allows increasingly complex procedures to be achieved with minimally invasive techniques.

In 1999, Intuitive Surgical (Sunnyvale, CA, USA) launched the *da Vinci* robot, a 'master-slave' device with a console controlled by the surgeon and robotic arms installed on a patient bedside cart. In 2003, Intuitive Surgical acquired its main competitor Computer Motion and has since dominated the market. Four generations of *da Vinci* robot later, and over 4,000 units sold worldwide, the *da Vinci* robot is the focus of >10,000 peer-reviewed publications examining the use of robotics in surgery.

Urologists have been at the forefront in harnessing the power of robotic technology to advance their surgical field. Robotic assisted prostatectomy, cystectomy, pyeloplasty, nephrectomy, and partial nephrectomy are all increasingly common techniques. More recently, a robotic device for endourological procedures has been trialed in humans [1].

Widespread introduction of surgical robots in urology occurred from the year 2000 onwards in the belief that they provided benefit to surgical outcomes over existing techniques. Concerns have been raised over the lack of high-level evidence to support the use of surgical robotic systems, considering the substantial additional costs they introduce [2].

Randomized controlled trial evidence comparing robot-assisted radical prostatectomy over an open retropubic approach failed to show any difference between urogenital or early oncological outcomes at 6, 12, or 24 weeks [3]. However the study did demonstrate a shorter operating time, reduced length of stay and estimated total blood loss [3]. While there are clear benefits of a robotic approach over open surgery in terms of short-term perioperative morbidity, the significant extra costs introduced by the robot are still questioned, and restrict expansion.

COST AND COMPETITION

The high cost associated with robotic surgery was partly explained by Intuitive Surgical being the sole producer of commercial robotic surgical systems. In 2019 a number of their intellectual property patents are due to expire. Competing master-slave system *Telelap Alf-X* by TransEnterix has now entered the market with sales made in Italy and Japan, and has an application with the U.S. Food and Drug Administration pending. Several other systems are also expected to be marketed within the next 5 years [4]. Increased competition, reusable instruments, and a resulting reduction in cost will lead to a stronger economic argument for robotic-assisted surgery, and expansion to more centers and regions is likely.

OPEN CONSOLES

The closed console of *da Vinci* envelops the surgeon's face and compromises his or her situational awareness within the operating theatre. *Telelap Alf-X* and the newer *Revo-I*, currently undergoing trials in Korea [5], promise open surgeon consoles with the potential to improve operating ergonomics. The *Telelap Alf-X* monitor requires the surgeon to wear 3D glasses and incorporates eye-tracking, whereas *Revo-I* boasts a 3D high definition monitor [4].

HAPTIC FEEDBACK

A major limitation of robotic surgical systems was the lack of haptic feedback compared to traditional laparoscopic technique. *Telelap Alf-X* is the first commercial robotic platform to incorporate haptic feedback technology. Via counter-movement of the console handles, the surgeon receives tactile information regarding force and its direction applied at the surgical site. Haptic feedback while operating increases surgical awareness and improves security.

SINGLE PORT SURGERY

Laparo-endoscopic single-site surgery (LESS) robotic systems are emerging technologies that allow multiple instruments and a camera to be inserted via a single incision. These robots further advance minimally invasive techniques, reducing surgical trauma and when an umbilical incision is used, approach scar-free operating. While experimental trials will be required to establish the benefit of LESS, they are expected to widen the gap between traditional and robotic surgical techniques. Both master-slave and bedside devices are being developed with Intuitive Surgical launching the SP 1098 single port platform for *da Vinci*, and competing systems from Titan Medical and TransEnterix [4].

BEYOND SURGICAL DEVICES

Robotics in medicine is not limited to surgical devices. One of the greatest healthcare challenges of the developed world is combating preventable disease caused by poor lifestyle choices. Researchers at the University of Southern California are developing socially assistive robots that interact with individuals to coach and motivate them towards a health or wellbeing goal [6]. With a call from the National Institutes of Health for research proposals for socially assistive robots, this field has potential to change management of difficult social issues such as weight loss and smoking cessation. If such goals are realized, socially assistive robots could be utilized to optimize perioperative comorbidities and thus improve surgical outcomes.

CONCLUSIONS

A range of competing robotic surgical systems is expected to enter the market in the next 5 years. The new technology offered has the potential to improve surgical ergonomics. With the market dominated by the high-performing but expensive generations of the *da Vinci* for almost 20 years, newer, economic machines may make robotic surgery accessible to wider populations.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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