Future of Surgery

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With 5 billion people lacking access to safe, affordable surgical and anesthetics care when needed, there has been much focus on the global challenge to change this dynamic, with goals set for improved access by 2030, in particular within low to medium income countries.[1] Whilst the UK does not fall into those categories, the need for integrated broad-based health-systems solutions is a key theme from the Lancet report that remains applicable to the current status of surgical access within the NHS. Even in a system as sophisticated as the NHS there is a wide variation in the type and quality of surgery on offer.

In this report, we consider the current barriers to providing patients access to the best care available within the NHS, and how, through innovation, the most advanced surgical options can be provided to patients, with all the associated benefits to society.

For hundreds of years surgery remained a very blunt tool with poor outcomes and limited success. High morbidity and mortality accompanied surgical endeavours. The inability to control pain during surgery, restricted access to any but the most basic interventions. This necessitated the use of speed as a way of limiting suffering during surgery. This was of course a cause of further morbidity. It was not until the introduction of inhalational anaesthesia in 1846 that significant advances could be made in surgery. As is so often the case, the advance that did the most to improve surgical success was not directly surgical.

From this point surgery developed rapidly and advances in instrumentation, the discovery of antibiotics and improved perioperative care led to massive improvements in outcomes. Gradually surgery progressed to enable intervention in advanced cancer and cardiac disease. Coupled with engineering advances orthopaedic operations revolutionised the lives of people with debilitating muscular and joint disorders.

Despite the improvements in surgical technique morbidity secondary to wound complications, poor post-operative mobility and post-operative pain remained high. From the

1960's teams started to experiment with minimal access surgery. The early stages of minimal access surgery (MAS) were hampered by inadequate visualisation and poor equipment. Improvements in vision systems, laparoscopes and insufflators allowed increasingly complex operations to be attempted safely via minimal access routes. In the 1990's rapid advances in equipment, improvement in training and widespread adoption by both the medical device industry and the profession contributed to a real increase in the number of procedures offered by a MAS route.

Fierce debate raged in the early years of MAS as to whether or not it offered real advantages over conventional surgery. Now there is a substantial body of Level I evidence demonstrating the benefits of MAS compared to open surgery across multiple surgical specialties.[2-10] Reduced risk of post-operative complications such as wound infections and venous thrombosis, decreased pain and use of narcotics, and reduced length of hospital stay and quicker time to return to normal activity are well documented outcomes following MAS compared to open procedures. The strong evidence base has led to a number of NICE recommendations supporting the adoption of MAS, including colorectal cancer, inguinal hernia repair and hysterectomy.

However, despite the evidence and positive NICE guidance, there continues to be underutilization of MAS across multiple common surgical procedures. Studies designed to query this discrepancy have confirmed that there is significant variation in MAS utilization across hospitals.[11-12] In a comprehensive review of the subject Cooper et al demonstrated that the complications associated with surgery in colorectal, gynaecological and thoracic surgery was halved by the introduction of MAS.[11] Post-operative mobility and pain management were also significantly improved. Despite all these improvements the same group was able to show that MAS still only provides for a minority of surgical cases. Similar findings were echoed in a recent publication reporting on the patient, surgeon, and hospital disparities associated with hysterectomy in the US.[12] Important ways to deal with this disparity include standardized postgraduate training, re-training of surgeons currently in practice, and better information for patients.

Despite all the technological advances of improved vision, enhanced insufflation and advanced instrumentation the majority of surgical procedures are still carried out via open surgery. There are two key aspects which are considered barriers. Firstly, despite improved training methods and systems only a minority of surgeons seem to be able to master the more complex tasks in laparoscopic surgery, in particular, laparoscopic suturing and intracorporeal knot tying.[13] Furthermore, despite the improved patient outcomes following MAS, current laparoscopic surgery is more demanding of the surgeon, leading to fatigue, discomfort and injuries.[14]

The first robotic surgical system received its FDA clearance in July 2000. Despite its technical advances after 17 years in regular use the system still only occupies 5-7% of the surgical market. Marcus et al reported a large variation in diffusion of robotic surgery in the UK, with several factors identified as influencing uptake. These included surgeon, patient and hospital-related factors. The high costs associated with the purchase and maintenance of current systems is almost certainly a major limiting factor preventing more widespread adoption.[15] Current evidence suggests that robotic surgery, under specific conditions, has the potential to become cost-effective. Higher utilization and the presence of competition are some of the factors that could help robotic assisted surgery become more reasonable and cost-effective.[16]

Therefore, the development of more sophisticated robotic platforms which can be used in multiple surgical specialities will ensure that the systems do not lie idle for long periods of time, increase the number of scrub practitioners familiar with the system and by so doing drive up the utilization in a hospital and improve the cost effectiveness of the technology. This may well provide the means of overcoming the barriers to MAS and so at last provide those MAS advantages to a far greater cohort of patients.

CMR Surgical has developed a small form, modular robotic surgical system to improve access to MAS. It has been designed to address some of the key unmet needs currently faced by the surgical community and therefore, should drive the advancement of improving access to robotic MAS. Due to its small form it is less difficult to store and can be shared between different theatres. The modular design will allow access to more complex positioning thus increasing its ability to perform many different types of surgery. The 5mm instrumentation will position it alongside conventional straight stick MAS but with the advantages of seven degrees of freedom in the instrumentation. The wristed instrumentation immediately removes some of the technical challenges inherent to laparoscopic surgery.

There is no reason why this technology will not be able to reproduce all the forms of conventional MAS surgery. However the robotic arms will allow greater freedom with port placement which may increase the number and range of MAS techniques. The surgeon works from an ergonomic position while sitting at an operating console, offering two key advantages. Firstly, this should enable them to extend their surgical career without the physical strain produced by conventional open and laparoscopic surgery. Secondly, the open console design enables improved interaction between the surgeon and bedside team.

Alongside the development of a new robotic system, CMR has designed a bespoke computer-aided simulator. Surgeons new to the system will be able to gain confidence and fluency with the system from the comfort of the office, in their own time and at a speed that suits them. Once comfortable with the console they will be able to progress to a box simulator before progression to a cadaveric training program. Improved and more efficient training will accelerate the progress to safe and effective surgery. This in turn will reduce the time sent training on patients and offer more opportunities to trainee surgeons. Advances in computer simulation will allow the development of a greater number of technical skills in the safety of the laboratory and further reduce the burden of training currently carried by patients.

The WHO check lists have been shown to markedly reduce surgical morbidity and mortality.[17] The robotic platform raises the potential of a number of features which will further support this concept. Operating from a console will allow the surgeon to follow a surgical "menu" ensuring a greater consistency and efficiency.

The system will record the entire procedure as well as capturing telemetric data from the arm movements and instrument usage. This will allow the development of algorithms that give insight into efficiency and allow refinements of the surgical techniques. Such a system may also collect valuable data for audit and surgical monitoring. This will also form the basis for the real time ongoing audit of the surgical procedure. This added to the post operative data collection will provide a very accurate record of the surgical outcomes of a surgeon. Such a system will provide insights into surgical techniques and could do much to enhance surgical safety.

In a short space of time repetitive functions, like knot tying, will be automated further reducing the physical strain associated with surgery. The addition of molecular fluorescent markers will enhance dissection and allow sparing of non-affected tissue during cancer surgery. Intelligent instruments such as the i-knife will further refine cancer surgery as a result of more accurate dissection and tissue sparing surgery.[18]

A successful robotic system will need to be adaptable to multiple theatres, able to perform surgery across a number of specialities, provide far greater utilisation and by so doing improve efficiency and drive down costs.

Like all the big developments in medicine it is often the ancillary functions that produce the greatest advances. The technical advantages of the robotic system will enable the surgeons to carry out more complex surgery safely and efficiently. However, the improvements in training, easier access to training, the use of advanced simulation and the analysis of telemetric and clinical data will have as much impact as the system itself.

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