Viewpoint

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Robotic Obesity Surgery, Possibilities and Application

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Robots are generally perceived as programmable mechanical devices that can efficiently and very precisely perform certain human functions and can increase safety. The concept originates in the Czech word, "robota," meaning compulsory labor, and takes the form of mechanical devices, some of which have been used in weight-loss surgery. I will discuss the current and future role of robotics in bariatric surgery.

While bariatric surgery has been shown to ameliorate a myriad of medical problems associated with obesity, such as diabetes and sleep apnea, we have seen obesity reach epidemic proportions not only in the United States but also worldwide. Prior to 1990, most bariatric procedures were performed by open operations, but the application of minimally invasive techniques to the Roux-en-Y gastric bypass attracted a new generation of surgeons to the field.[1] Industry immediately saw the vast potential of minimally invasive bariatric surgery and poured resources into the training of surgeons.

About Article

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Extracorporeal tools facilitate every bariatric surgical procedure, as extensions of the surgeon's hands. The wealth of information that comes from experienced tactile contact with tissues, temperature, pressures, and motion cannot readily be improved upon; however, the challenges to delicate handwork in tight, sometimes unvisualizable locations, and ergonomic wear and tear have contributed to the impetus toward laparoscopic instrumentation, and in the last decade, to robot-aided surgery. These computer-guided assistants lack the knowledge and sensory finesse to perform surgery, but in specific applications, offer dramatic benefits, including the automation of tasks, performance of repetitive motions...

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New and improved instrumentation and medical devices were also developed that benefited the entire field of minimally invasive surgery. The number of laparoscopic fellowships around the country has now grown markedly, and most place a strong emphasis on bariatric surgery.

The Trend to Minimally Invasive Techniques

Laparoscopic bariatric surgery is very complex and technically demanding. A learning curve of 75–100 cases is proposed by many authors such as Shauer and Shikora.[2,3] For many, this learning has now become feasible in Minimally Invasive Surgery (MIS) fellowships; however, for many other surgeons who were in practice prior to 1990, the task of switching to MIS techniques from open surgery has been daunting. Intracorporeal suturing is particularly difficult, and the consequences of a failed suture line, devastating. Failed suture and staple lines result not only in considerable morbidity and mortality for patients, but also in litigation and skyrocketing malpractice insurance costs. The payers have also been influenced by the high cost of managing such complications and, in general, have restricted patient access to bariatric procedures.

Robot-Assisted BPD/DS

With many of these concerns in mind, I explored use of the da Vinci® robotic system (Intuitive Surgical, Sunnyvale CA) after it received Food and Drug Administration (FDA) approval in 2000. In October of the same year I performed the first robot-assisted (RA) bowel resection, and later that month, we performed the first totally intracorporeal RA biliopancreatic diversion (BPD) with duodenal switch (DS) operation (RA-BPD/DS).[4,5] At that time, the BPD (originated by Scopinaro,[6] and the DS modification, by Hess,[7] and Marceau,[8] independently) had been described...

...and the ability to sustain torque while working in angular positions with their mechanized wristed joints (particularly in morbidly obese patients with thick abdominal walls). Robot assistance has returned some of the human hand and wrist acumen of open surgery to minimally invasive surgery that standard laparoscopic instrumentation lacks. In addition, the robotic platform has the capacity to interact with other digital data sources, such as computed tomographic imaging, delivering an information-rich, augmented reality to the surgical field.

Still, some feel that the learning curve, the cost of the robotic platform, and the minimal tactile feedback on tissue, requiring the surgeon to rely almost entirely on stereoscopic visual cues, may be significant impediments to its future widespread adoption (Wilson EB. Scand J Surg, 2009). A recent systematic review and meta-analysis (Maeso S, et al. Ann Surg, 2010) of 31 studies (6 randomized controlled trials) with 2166 patients...

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by Gagner in its laparoscopic form,[9] employing an EEA stapler for the duodenojejonostomy. In our attempts to use the EEA for the duodenojejunostomy, we recognized that only a small-size stapler shaft could be accommodated in the narrow distal ileum and insertion often risked tearing the bowel. I was also concerned about post-pyloric stenosis with the EEA technique. Since I had been performing open DS procedures using a hand-sewn anastomosis, I elected to duplicate the open technique using the da Vinci system. In the DS procedure, the stomach capacity is restricted to 150 cc by performing a sleeve gastrectomy in which the pylorus and the first 4 cm of the duodenum are preserved. A common channel of 100 cm and an alimentary canal of 250 cm are created; these malabsorb fatty foods while the absorption of simple sugars and peptides is preserved. Many surgeons worry about the metabolic complications of the BPD/DS; however, Marceau reported a significant decrease in protein malnutrition, diarrhea, and bone pain in the DS group compared to standard BPD. Serum ferritin, calcium, and vitamin A levels were higher and the ulceration rate was also very low after BPD/DS.[8]

The robotic BPD/DS is currently performed using 5 ports. The distal bypass is created laparoscopically, whereas the duodenojejonostomy is performed using the da Vinci system. Standard laparoscopic staplers are used to perform division of bowel and the sleeve gastrectomy. Our technique for performing the robot-assisted BPD/DS in morbidly obese patients, resulting in low morbidity and no mortality, has been published in *Surgical Endoscopy* (2007).[10] Other techniques including hand-sewn anastomosis by conventional laparoscopy, linear cutter staplers, and hand-assisted techniques have also been described in the literature.[11-14]

...found that the robotic platform provided a more rapid intestinal recovery time after gastrectomy (and thus, shorter hospital stay), briefer hospital stay after cholecystectomy (though time in surgery was greater), longer time in surgery in colorectal resections, and in gastric bypass, more conversions to open surgery. Though robotic-assisted surgery is currently performed in numerous clinics in the United States (>700 robotic surgical systems), whether it provides a true advantage over standard laparoscopic techniques is unknown. In this month's Viewpoint column, Dr. Ranjan Sudan, a pioneer in the use of robotics in surgery, and the metabolic/bariatric surgeon with the largest series of robotically performed biliopancreatic diversions with duodenal switch, reviews the evolution of robotics in the field. Dr. Sudan discusses the learning curve, the safety and efficacy of the robotic platform, and his thoughts on the future of the technology.

Previously, computer-assisted technology was offered by Computer Motion, Inc. and Intuitive Surgical, Inc. With the consolidation of the two companies, the Zeus® surgical system is no longer available and the AESOP® camera system with the Hermes® voice activated system are being phased out in most institutions, including ours. However there have been many exciting innovations in robotic surgery systems since the first generation machines were introduced about ten years ago.

Benefits and Limitations of Robot-Assisted Bariatric Surgery

The benefits of several degrees of freedom, three-dimensional vision, and motion scaling using robotic technology are well known. These advantages help novices perform intra-corporeal suturing and Roux-en-Y gastric bypasses faster with robotic technology than with conventional laparoscopy.[15] However, for skilled bariatric laparoscopic surgeons, the perceived benefits of the robotic technology have not offset its expense, the need for trained personnel, and the associated time commitment.[16]

The bariatric surgeons of today are extremely adept in suturing and stapling and can accomplish the same tasks faster and more economically by conventional laparoscopic techniques. Hence, for this professional group, using the robot for the adjustable gastric band, Roux-en-Y gastric bypass, and the sleeve gastrectomy may be a hard sell. The robot appears to be best suited to working in a small space, when precision is required (e.g., lymph node dissection in the pelvis, suturing the urethra in prostatectomy,[17] performing tubal reconstructions). This has been the reason for its widespread adoption in urology, gynecology and, increasingly, in colorectal surgery. However, these situations are encountered infrequently in bariatric surgery. I have successfully used the robot to perform stricturoplasties for sleeve strictures, malrotation, and a duodenal stump leak after a BPD/DS that was undetectable and not accessible with conventional laparoscopy.[18,19] I also routinely use the robot for performing the proximal anastomosis in the BPD/DS. Robotics may also have a role in revision of bariatric operations when tedious dissection is required. Dual console technology is another advance that is used for mentoring trainees and such innovations increase patient safety.

Robotics is here to stay, and if the stock price is any indication, its growth as predicted by Wall Street is likely to continue. Robotics may find a new role in bariatrics, given the current craze of single-incision laparoscopic surgery. A robotic platform is ideally suited to overcome many of the ergonomic issues that face conventional single-incision laparoscopy. Ergonomics is also important when dealing with patients with high abdominal wall torque, which can easily impair a surgeon's fine motor coordination and cause fatigue. As laparoscopic surgeons age, the chronic

strain and stress of conventional laparoscopy will tell on their bodies. I, personally, have noticed the benefits of robotic technology in this regard.

In the last ten years I have learned much about the use of robotic technology and many of its limitations. This process has expanded my surgical horizons and my enthusiasm for the technology remains very high. I also recognize that the field of robotics in surgery today is where laparoscopy was more than thirty years ago—much more development lies ahead.

Dr. Sudan has no financial relationships that pose a conflict of interest with this column.

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Dr. Sudan joined the faculty at Duke University Medical Center in Durham, North Carolina as Vice Chair for Surgical Education in the Department of Surgery in 2008 and has had a long-standing passion for education. He is board certified in both psychiatry and general surgery. Formerly, he was Director of the Bariatric Fellowship Program, Director of the General Surgery Residency Program, and Associate Chair of Medical Education at Creighton University Medical Center, Omaha, Nebraska. Dr. Sudan also completed a residency in Psychiatry and finished his training in Adult Psychiatry at Wright State University, Dayton, Ohio and subsequently, in Child and Adolescent Psychiatry at Columbia University, New York. After residency, Dr. Sudan decided to specialize in Bariatric Surgery, as this field combines the technical expertise of surgery with many elements of psychiatry. He developed a Bariatric Surgery program at the University of Nebraska, and later at Creighton University Medical Center, which became the flagship for the hospital. His area of special interest is the application of the da Vinci® robotic system to complex surgical procedures. In 2000, Dr. Sudan performed both the first robot-assisted bowel resection and the first duodenal switch using the da Vinci system, and has gone on to demonstrate the feasibility of performing complex urologic procedures robotically (e.g., total cystoprostatectomy with ileal conduit). Dr. Sudan has published these techniques and has given several national presentations.

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