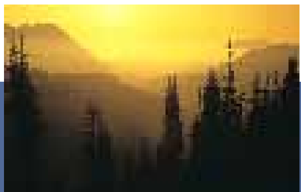
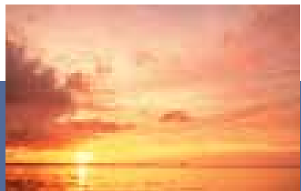
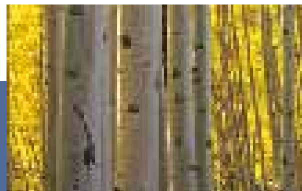
Advances in Colorectal Surgery

The Introduction of Robotics

Laparoscopic surgery continues to gain popularity for a variety of abdominal and pelvic operations. Minimally invasive surgical techniques result in less tissue injury which results in many advantages over conventional open procedures. Less postoperative pain, shorter hospital stay, quicker return to normal activity and work, as well as decreased perioperative morbidity and need for blood transfusions have all been documented compared to open surgery.

Traditional Laparoscopic Surgery and its Limitations

Universal acceptance of minimally invasive surgery for complex abdominal and pelvic operations has been hindered secondary to several technical limitations of laparoscopy. One of the major pitfalls of laparoscopy remains adequate visualization. Unlike open surgery, laparoscopy provides a two-dimensional image. Additionally, the laparoscope is positioned on an unstable platform and relies on a trained assistant who is often expected to anticipate the operators movements. Traditional laparoscopic instruments have also limited laparoscopic progression. Long laparoscopic instruments can amplify physiologic tremors and their tips are fixed and unable to provide “wrist-like” movements. The standard fixed instruments only provide four degrees of freedom (in-out, up-down, left-right, rotation of the shaft) which limits natural movements. While performing laparoscopic procedures, surgeons are often forced to overcome the limitations of laparoscopic instruments by positioning themselves in awkward and uncomfortable positions. The resultant poor ergonomics has been implicated in surgeon fatigue and decreased efficiency and patient safety 1,2.

Advantages of Robotic-Assisted Surgery

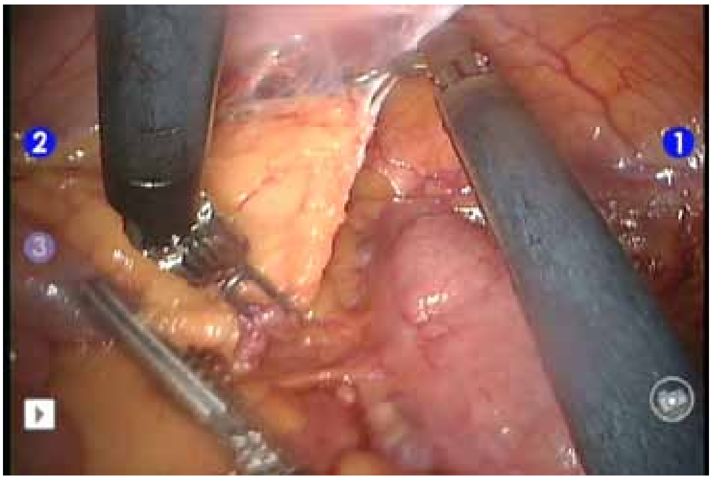
Robotic-assisted surgery has been developed to address several of the limitations of conventional laparoscopy and is quickly increasing the ability to perform several abdomino-pelvic operations employing minimally invasive techniques. The telerobotic system generates a stereoscopic three-dimensional image which facilitates depth perception and provides improved visual feedback. The image created also allows improved magnification helping clarify tissue planes during dissection. Additionally, in robotic-assisted surgery, imagery is under the surgeons’ direct control and the visual platform corrects for physiologic hand tremors providing increased precision. One of the biggest advantages has been in the development of surgical instruments. Robotic instruments provide seven degrees of freedom which mimics natural hand movements and dexterity (Picture 1). During surgery, the operator is seated at a console in a comfortable anatomic position. This improvement in ergonomics has eliminated the uncomfortable and awkward movements of traditional laparoscopic surgery and reduces surgeon fatigue 3 .

History of Robotic Surgery and its Current Applications

The first robot to be used during surgery was named Aesop created by Computer Motion, Inc. This was first used in 1996 and was a simple device used to control the position of the laparoscope. This led way to the development of Zeus which was the first robotic system which controlled surgical instruments as well as the camera. In 2000, the daVinci Surgical System (dVSS) (Intuitive Surgical, Inc., Sunnyvale, CA, USA) became the first fully operational robotic system approved by the US Food and Drug Administration (FDA) for use in general surgery. Shortly thereafter, the FDA approved the dVSS for use in urologic, gynecologic, and cardiothoracic procedures. One of the earliest applications with the robot occurred in cardiac surgery. The improved dexterity, imaging and tremor reduction proved to be beneficial for arterial anastamoses during coronary artery bypass grafting (CABG). Since then, cardiac surgeons have broadened its applications and have performed several other procedures including mitral valve replacements, as well as closure of atrial septal defects, patent ductus arteriosus, and ablations for atrial fibrillation 4 .

Urologists have been one of the largest groups pleased with the robot for performing prostate surgery largely due to the ability to suture within the narrow male pelvis. Robotic-assisted surgery is quickly becoming the gold-standard for prostatectomies. The number of hospitals offering this operation has drastically increased from 1,500 cases reported in 2000 to over 80,000 robotic pros-

Picture 1: Intraoperative picture of lysis of adhesions with the wrist motion seen at the end of the instrumentation for the hook and the grasper



tatectomies being reported in 2008 5. Urologists have found several advantages of robotic prostatectomies compared to open procedures. Decreased blood loss is a frequently reported benefit of robotic prostatectomy and has resulted in fewer blood transfusions compared to open prostatectomies. Complications of prostatectomy including anastomotic leaks, urinary tract infections, trocar injuries, pulmonary embolisms, deep venous thrombosis, and anastomotic strictures have all decreased with the use of the robot. In a recent review, the overall complication rate of robotic prostatectomy was 6.6% compared to 15.6% for laparoscopic prostatectomy and 10.3% for open prostatectomy. Patients have also benefited from improved oncologic outcomes. Robotic prostatectomy is associated with the lowest rate of positive resection margins. Robotic prostatectomy has yielded a positive resection margin rate of 12.5% compared to 19.6% for laparoscopic prostatectomy and 23.5% for open prostatectomy. Given the ability to perform nerve sparing operations with the assistance of the robot, studies have also shown improved postoperative urinary continence rates and decreased rates of sexual impotence. Although critics of robotic assisted surgery often quote prolonged operative times, improved training and increased volumes have cut down on the time required to perform robotic surgery. The mean operative time of robotic prostatectomy (164 minutes) has approached that of open surgery (147 minutes) and has surpassed laparoscopic prostatectomy (227 minutes) 6.

Robotic Colorectal Surgery

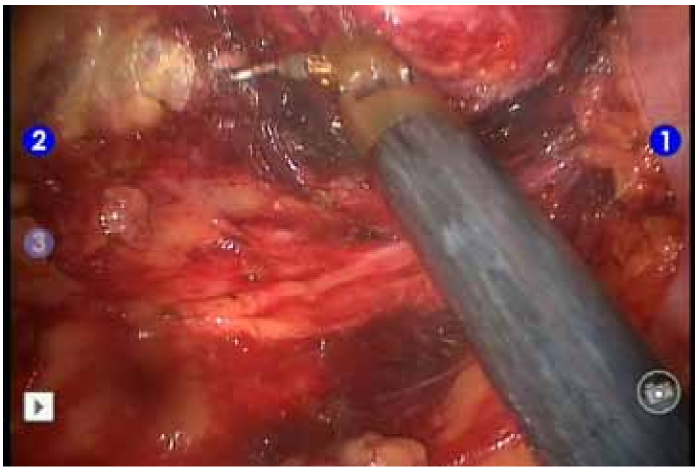
Several of the advantages experienced with robotic urologic surgery are translating into benefits for colorectal surgeons. Working within the confined spaces of the pelvis, while preserving pelvic autonomic nerves, has provided challenges to performing laparoscopic surgery for rectal operations. Technical improvements with robotic surgery have proven to be beneficial when performing mid to low rectal dissections and studies are emerging reporting its benefits to treat both benign and malignant disease.7

Benign Disease

Suture rectopexy is one option for the treatment of rectal prolapse. This procedure has traditionally been done via midline laparotomy with dissection of the rectum down to the pelvic floor. If a significant amount of redundant sigmoid colon is present, a simultaneous resection of excess colon may be performed at the discretion of the operating surgeon. The lateral attachments of the rectum are then sutured to the presacral fascia to prevent a recurrence of prolapse and allow time for scarring to develop in the pelvis. There is miminal margin for error, as the presacral venous plexus lies close by, and can result in life-threating hemorrhage if injured.8 A laparoscopic approach to this technique has also been used with some success, particularly when a resection is not planned. Placement of the sutures in the presacral fascia has proved challenging even in the most experienced of hands. Visualization is often suboptimal after mobilization of the rectum and the angle of entry of the laparoscopic needle driver is not ideal. Robotic assisted suture rectopexy combines improved retraction and visualization with better angulation of the needle to provide a more precise suture placement. This gives it the strength to secure the rectum and minimizes unintended injury to the presacral veins. Heemskerk et al recently compared a robotic approach to rectopexy with conventional laparoscopy and noted similar complication rates and hospital stays in both groups, with only a higher cost in the robotic arm separating the two groups.9 This is a well recognized detraction of robotic surgery, but the costs will likely level out over time, as they have with other technologies.

Diverticulitis and its complications (abscess, fistula, stricture) represent one of the most common indications for sigmoid colectomy in the United States. The risk of developing diverticular disease is 5% by age 40 and 80% by age 80.10 Patients with recurrent or complicated disease are

Picture 2: Intraoperative view of a total mesorectal excision using the da Vinci Surgical System



often counseled to undergo elective surgery to avoid the possibility of emergent surgery, which can require a colostomy. Laparoscopic sigmoid colectomy is now performed routinely on an elective basis to remove the diseased portion of colon and avoid a stoma. Robotic assistance can facilitate dissection along the left gutter and provides excellent visualization of the left ureter, which can be difficult to identify laparoscopically. Dissection through the mesentery of the colon is clearer due to the magnification, allowing intracorporeal ligation of vessels as well as transection of the distal colon, allowing removal of the specimen through a much smaller incision. In our own experience, which is as yet unpublished, 7 of our first 20 robotic cases were sigmoid colectomies for diverticulitis, and the average procedure time was 132 minutes, which compared similarly to our laparoscopic cases. Anecdotally, we have noted that the operative times have been decreasing as the surgeons become more comfortable with the system, such that procedure times may even become favorable to laparoscopy. Our average length of stay was 4.8 days, with a 30 day complication rate of 43% (3/7 patients.) One patient was readmitted with post-operative ileus, one was treated in the ER for constipation, and one patient had a post-op MI. These results demonstrate only a small sampling, but provide evidence that the outcomes of robotic assisted colectomy for diverticulitis will likely be similar to those of laparoscopy.

Malignancy

The treatment of rectal cancer is where the major application of robotics in colorectal surgery appears to exist. Total mesorectal excision was championed by Heald as a surgical technique that would remove the rectum with its mesentery encased in a fascial envelope. This approach has altered the surgical treatment of rectal cancer, providing an operation with a low local recurrence rate and satisfactory functional outcomes. However, this meticulous pelvic dissection requires adequate exposure and is often an exhausting procedure. Laparoscopy has provided some improvement in visualization, but has the drawback of increasingly awkward positioning, as one is often leaning over the patient's abdomen to handle instruments placed on either side. The use of robotic assistance provides unmatched visualization, improved retraction through the use of the articulating graspers/retractors, and less surgeon fatigue as the instruments and camera are held steady by the robot (Picture 2 and Picture 3). When Spinoglio et al reported on their early robotic experience, 19/50 (38%) were low anterior resections (proctectomies) for rectal cancer. They reported only one anastomotic leak (5%) which is quite a respectable figure for coloanal anastomoses. This group also reported that lymph node clearance was similar between their robotic cases and acohort undergoing the same procedures via traditional laparoscpic approach, although actual numbers were not provided.11 While it is understood that a trial is still underway to determine the safety of laparoscopy in rectal cancer, these early data regarding robotics provide encouragement going forward.

Short term outcomes after robotically assisted TME have been reported in a 2 year experience by Hellan et al.12 in their series of 39 patients, 56.4% underwent low anterior resection, 28.2% coloanal anastomosis and 15.4% abdominoperineal resections. The operative time averaged 285 minutes with a mean operating time performing the TME portion of the procedure of 60 min. Their average length of stay in the hospital was 4 days without any mortality. Four patients suffered anastomotic leaks that required of reoperation and diverting stomas that were subsequently reversed. Upon evaluating their series for oncologic results, the average number of lymph nodes retrieved was 13. The mean distal margin was 2.6 cm. This data clearly indicates the feasibility to perform cancer curing operations with this technology. At a median follow up of 13 months (range 2-29) there were no local recurrence and 4 patients had developed metastatic disease.

The most compelling work published to date is

Picture 3: Intraoperative view of the mesorectal dissection with x10 magnification

a randomized trial in robotic versus laparoscopic TME by Baik and colleagues. 13 In their study, 113 patients were originally randomized to laparoscopic low anterior resection L-LAR(n=57) or robotic resection R-LAR(n=56). In their randomization protocol there were 8 patients that crossed over from R-LAR to L-LAR and 6 L-LAR to R-LAR ue to patient preference. At that point, the study was converted to a prospective non randomized. The patient's demographics were the same as well as the location of the tumor from the anal verge (9.6 cm robotic, 9.5 cm laparoscopic) were similar between the groups. Preoperative chemoradiation was done in 8.9% of the R-LAR and 12.3% in the L-LAR.

Interestingly, the R-LAR and L-LAR times were similar (190.1 min vs 191.1 min, respectively). There were no conversions in the R-LAR and 6 patients were converted to open in the L-LAR (P= 0.01). Days to advance to a soft diet and hospital length of stay was significantly shorter in the R-LAR (4.7 days and 5.7 days, respectively) when compared to the L-LAR (5.5 days and 7.6 days) (P<0.08). There was one anastomotic leak in the R-LAR and 4 in the L-LAR and the overall complication rate for both groups was statistically significant favoring the R-LAR.

The mean number of harvested lymph nodes was 18.4 in R-LAR similar to L-LAR. The distal margin was also similar between the groups (4.0 cm R-LAR and 3.6 cm L-LAR).

At a median follow up of 13 months, there were no local recurrences in either group. There were however 2 systemic recurrences in the L-LAR and 2 as well in the R-LAR arm. All 4 of those patients were stage III disease.

Although these results represent early work, all of them performed by individual surgeons with significant skill and experience in pelvic surgery, the findings seem to be in agreement with the notion that the performance of the oncologic surgical dissection in the pelvic floor is at least as good with perhaps less conversion rate than the laparoscopic techniques. One could easily attribute the ergonomics and magnification of the dVSS towards this advantage.

Conclusion

The treatment of patients with surgical diseases has long relied on innovation and technology. As our tools become more advanced, so does our ability to care for patients. Robotic surgery is the newest technological advancement in the field of colorectal surgery, and its unique attributes make it a desirable tool for pelvic floor surgery. While the increased costs and resource utilization associated with robotic surgery cannot be overlooked in this difficult healthcare environment, we must find the most appropriate ways to employ these new 21st century tools. Improving visualization and dissection deep in the pelvis has long been a goal for the colorectal surgeon, and the assistance of robot may make a monumental difference in the outcomes and quality of life in our patients, who are the reason this technology has developed.

References:

1 . Oleynikov D. Robotic surgery. Surgical Clinics of North America 2008; 88: 1121-1130.

2. Stylopoulos N, Rattner D. Robotics and ergonomics. Surgical Clinics of North America 2003; 83: 1321-1337.

3. Intuitive Surgical. 2004. Available at: www.intuitivesurgical.com. Accessed May 10, 2009.

4. Sundt T. What's new in cardiac surgery. Journal of the American College of Surgeons 2003; 196: 768-777.

5. Haas E. Robotics are coming to colorectal surgery. General Surgery News 2009; 36: 32-35.

6. Berryhill R, Jhaveri J, Yadav R, Leung R, Rao S, El-Hakim A, et al. Robotic prostatectomy: A review of outcomes compared with laparoscopic and open approaches.Urology 2008; 72: 15-23.

7. D'Annibale A, Morpurgo E, Fiscon V, Trevisan P, Sovernigo G, Orsini C. Robotic and laparoscopic surgery for treatment of colorectal diseases. Dis Colon Rectum 2004; 47: 2162-2168.

8. Vernava AM, Beck DE. Rectal Prolapse. ASCRS Textbook of Colon and Rectal Surgery 2007; 665-677.

9. Heemskerk J, de Hoog D, van Gemert W, Baeten C, Greve J, Bouvy N. Robot-assisted vs. conentional laparoscopic rectopexy for rectal prolapse: a comparative study on costs and time. Dis Colon Rectum 2007; 50: 1825-1830.

10. Thorson A, Goldberg S. Benign Colon: Diverticular Disease. ASCRS Textbook of Colon and Rectal Surgery. 2007; 269-285.

11. Spinoglio G, Summa M, Priora F, Quarati R, Testa S. Robotic Colorectal Surgery: First 50 Cases Experience. Dis Colon Rectum 2008; 51: 1627-1632.
12. Hellan M, Anderson C, Ellenhorn J, Paz B, Pigazzi A. Short term ourcomes after robotic assisted total mesorectal excision for rectal cancer. Ann Surg Oncol 2007; 14 (11): 3168-3173
13. Baik SH, Kwon HY, Kim JS, Hur H, Sohn SK, Cho CH, Kim H. Robotic versus laparoscopic low anterior resection of rectal cancer: short term outcome of a prospective comparative study. Ann Surg Oncol 2009; 16; 1480-1487

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