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A research study on Outcomes of latest surgical techniques and technologies in the treatment of colorectal cancer, such as minimally invasive procedures, robotic surgery approach

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ABSTRACT

Background: The minimally invasive surgery maintained the advantages while total mesorectal excision treatments for the rectal cancer are made simpler using the advanced robotic technologies.

Objective: To comparison to the traditional laparoscopic surgery, and robotic surgery for the rectal cancer results in reduced rates of conversion and a quicker return of urogenital function. However, the main drawbacks of robotic surgery are the prolonged operation time and exorbitant cost.

Results: In comparison to laparoscopic surgery, mostly other short-term surgical results, the pathologic outcomes, and the long-term oncologic outcomes of robotic surgery have not yet demonstrated any appreciable improvements. However, because it significantly lessens the burden and learning curve for the surgeon, robotic surgery is still a viable and eagerly awaited surgical method for the rectal cancer. Additionally, there are benefits when using robotic techniques for intricate surgeries like intersphincteric excision or lateral pelvic lymph node dissection.

Conclusion: It is anticipated that the advent of the new surgical robot systems, such as da Vinci® SP system, would broaden the uses of robotic surgery and offer additional benefits.

INTRODUCTION

The development of the minimally invasive surgery has been the major problem in surgery during the past few decades. [1] The da Vinci® Surgical System's use in the surgery has presented doctors having both opportunities and difficulties. Modern technology have significantly aided in overcoming the technical challenges associated with traditional laparoscopic surgery, including enhanced three-dimensional vision that is controlled by the operator, efficient counter/anti traction with articulating motion, and the tremor reduction. [2] Surgery carried out in constrained areas, where advantages of the surgical robotic system could be maximised, has actively used these techniques.[3] Rectal surgery has been the principal application of the robotic technologies in field of the colorectal surgery. [4] Rectal surgery is extremely challenging because it must be carried out in the bony pelvis, a confined location with many important surrounding structures, including the urologic and gynaecologic organs, median sacral and the iliac arteries and sacral nerve plexus. On other side, it's a field surgery were using a robotic device rather than a laparoscopic equipment with limited movement has considerable advantages. Robotic surgery has been used successfully in benign rectal procedures like the rectopexy for the pelvic organ prolapse and the restorative proctocolectomy having IPAA (ileal pouch-anal anastomosis) in patients possess IBD

(inflammatory bowel disease),[5–7] but the majority of reports on the robotic rectal surgery had cases of the rectal cancer. Meanwhile use of the robotic technologies in treatment of the colorectal cancer, there has been debate regarding whether or not the results will be better than with traditional laparoscopic surgery. The outcomes of the robotic surgery for the colorectal cancer, particularly the rectal cancer, are outlined in this section along with some future prospects for robotic surgery.

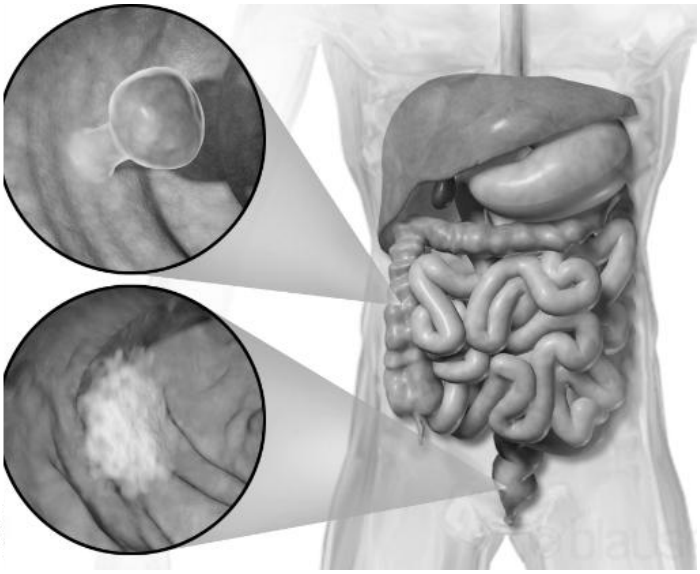

Figure 1. Colorectal cancer

ROBOTIC SURGERY FOR THE RECTAL CANCER's OUTCOMES

Short-term outcomes of surgical

The operating time was significantly longer with robotic rectal cancer surgery compared with traditional laparoscopic surgery meta-analyses that is published and RCTs (randomised controlled trials).[8] This is due to the extra time needed for docking robotic arms and placing instrumentation. Additionally, robot surgery consumes more time since surgeon must should do each movement sequentially by itself, whereas traditional laparoscopy allows an assistant, surgeon, and a scopist to move concurrently. Due to the robotic system's specialisation in motions carried out vigorously in a small space, a significant contributor to the lengthened operation time is the absence of wider-range mobility. One major downsides of the robotic surgery is that there is limits that how much gap at time of operation can be reduced even after the mastering, learning curve.[9] On the other hand, the main benefit of the surgery of the robotic rectal cancer in terms of the immediate results may be the much-decreased conversion rate to the open surgery.[10] The patients who had received surgery robotically have the much lower rates of conversion than who had underwent the laparoscopic surgery, according to a review of the National Cancer Database and multiple meta-analyses.[10] Although there was no difference in the two groups' overall conversion rates in the ROLARR study, the robotic surgery group's conversion rate was considerably lower in the obese and male patients having low rectal cancer.[11] This is because the robotic system's cutting-edge technology enables it to enter spaces and do tasks that are challenging for a laparoscopic instrument, making it feasible to easily overcome the barriers that prevent conversion. Lowering the rate of conversion had significant clinical benefits since the open surgery has significant impact on the both immediate and the long-term results.[12] The benefits of this robot system can be seen surprisingly in the mobilisation of the splenic flexure (SF), as well as in the pelvic phase. Iatrogenic splenic damage happens in roughly 0.4 percent of patients, and the splenic flexure mobilisation is the most challenging steps in colonic phase of

the rectal cancer surgery. [13] Recent studies claim that controlled traction made possible by greater anatomic vision during robotic surgery enhances mobility and permits more efficient SF mobilisation. This is frequently cited as justification for the completely robotic procedure, which uses a robotic system to perform surgery during both pelvic and colonic phases, as opposed to hybrid technique, which uses system of robotics only during pelvic phase. Robotic surgery did not exhibit clear advantages in other terms, the short-term outcomes like the post-operative and intra-operative rates of complication or the length of stay in hospital. The robotic surgery is anticipated to provide the benefit of lowering transfusions because the certain studies have shown that estimated loss of blood in obese individuals is lower when it is conducted. [12,13] However, there was no discernible difference between the laparoscopic surgery and the robotic surgery in the majority of outcomes of surgery, likewise the anastomotic leakage. This might be due to major procedures and intraperitoneal access in robotic surgery are carried out similarly to those in laparoscopic surgery. Since robotic staplers have recently been used, we are awaiting data demonstrating whether they can lessen the possibility of anastomotic leakage and stapling failure at the rectal division line.

Figure 2. Robotic Rectal Surgery

Long-term pathologic and oncologic outcomes

Robotic system is intended to help with enhancing the completeness of TME (total mesorectal excision) and securing the CRMs (circumferential margins) through outstanding stable traction and magnified vision and the dissection when this was implemented in rectal cancer surgery. Improved pathologic results were also expected to decrease the local recurrence and increase the survival. Though, in majority of trials, including ROLARR trial, no difference was there in CRM positive and quantity of removed lymph nodes between robotic and the laparoscopic surgery. [14] Robotic surgery has been associated with a larger distal resection margin in some studies, but due to the high degree of heterogeneity within studies, it is challenging to draw broad conclusions. [15] In terms of pathologic outcomes, there may not be a difference between the two groups because laparoscopic surgery is now more frequently utilised than in

the past and the standard of the procedure has increased. Along with these pathology findings, robotic surgery failed to outperform laparoscopic surgery in terms of oncologic outcomes.[16] Although there are few trials providing oncologic outcomes at this time, most of these papers found no appreciable difference between two groups in terms of the overall survival or the disease-free survival. These oncologic outcomes would appear acceptable given that the pathologic results were comparable.[17] Future research findings, including those from COLRAR and RLOAPR trials are anticipated.

Figure 3. Robotic assisted oncologic surgery.

Functional outcomes

Urogenital functional outcomes are a significant problem in rectal surgery. Up to the 60% of the women and 80% of the men may develop permanent or temporary sexual dysfunction following the rectal surgery as a result of nerve damage to inferior or superior hypo-gastric nerve plexus, which frequently cause voiding and sexual dysfunction during the procedure.[18] The robotic system's enlarged eyesight and accurate movement were anticipated to reduce nerve damage and enhance urogenital function. Sadly, neither the ROLARR experiment nor extensive retrospective analyses revealed any appreciable variations in the urogenital function between the laparoscopic and robotic surgery. The superiority of the robotic surgery in terms of functional results is still debatable to this day, while some studies have found that the robotic surgery group recovered to the normal sexual and voiding function more quickly than the group of laparoscopic surgery.[19] More research is needed to accurately quantify this parameter because radiotherapy, the presence of a stoma, and patient emotional factors all have an impact on urogenital function in addition to nerve injury.

Cost analysis

The high expense of surgery of rectal cancer by robotic is one of its main disadvantages. The robotic surgery was more expensive than the laparoscopic surgery in the majority of institutions and countries, while the mechanism for covering medical costs varies from the country to country and amount also varies across the institution to institution. [20] According to a number of studies, robotic surgery costs between 1.3 and the 2.5 times more than the laparoscopic surgery, that presents a barrier for the individuals who might be interested in having it. The fact that profit returned to hospital is relatively low and overall cost socially rises when compared to the laparoscopic surgery is another economic shortcoming of robotic surgery, According to certain publications, robotic surgery can actually lower hospital costs because there is a low rate of conversion to the open surgery, which reduces related length of hospital stay and morbidity. [21] In nations like the United States, where hospitalisation expenses are considerable, this effect is anticipated to be more pronounced. Additionally, it has been reported that the price drops as operator expertise grows.[20] Additionally, we anticipate that the price of robotic surgery will drop if different businesses other than the current monopoly supply surgical robots in the future.

PROMISING ASPECTS IN THE ROBOTIC SURGERY

Workload and learning curve

Even though laparoscopic surgery has gained popularity, performing a sufficient quality of the laparoscopic surgery is still challenging, and it necessitates the sizable number of the cases along the curves of learning. Rectal surgery particularly more challenging than colonic surgery. Limitations like stiff or weak instruments of laparoscopy and challenging synchronisation between assistant, operator, and the scopist are to blame for this. Due to this, robotic surgery has quicker curve of learning than the laparoscopic surgery since surgeon might control camera and assisting device, enabling stable and forceful traction. [22] Proper care must be taken while the interpretation of the outcomes of these trials because prior expertise with laparoscopic surgery has a significant role in curve of learning for the robotic surgery. However, some surgeons choose to learn robotic surgery without first gaining laparoscopic expertise through traditional open surgery.[22] With help of robot system, both inexperienced and seasoned surgeons can use minimally invasive surgery more frequently and effectively.

Application to colon cancer

Due to the technical advantages of robotic system for the surgery in small area, robotics has mostly been used for rectal surgery in colorectal surgery. The mobility is somewhat less than that of laparoscopic surgery for the treatments requiring the wide range, such as colonic part of the rectal surgery. As a result, hybrid approach, which uses a robotic device solely during the pelvic phase, is more frequently utilised in rectal surgery. In the meantime, arguments in favour of and against using robotic system for treating cancer of colon have persisted. It is due to the fact that the surgery of colon cancer is typically carried out in large cavity of abdomen, making benefit of the robotic technologies over the laparoscopy less clear. [23] Due to this, robotic surgery has not been used frequently to treat colon cancer, particularly colon cancer on the left. Robotic surgery for colon cancer has several benefits, nevertheless, one of them is that intracorporeal anastomoses are simple. Anastomosis is routinely carried out extracorporeally with a stapler even in event of the laparoscopic surgery of right-side colon. This is because laparoscopic equipment is difficult to use to perform sutures, especially while closing the common channel of bowel, and intracorporeal anastomosis even with an articulated laparoscopic stapler is challenging to handle. Robotic systems are reportedly useful in this process, according to several research [9,10]. This is possible that avoid an overly broad range of the dissections of colon because intracorporeal anastomosis can be carried out more simply utilising a robotic articulating stapler (e.g. routine hepatic flexure mobilization). By relocating the site for specimen extraction to Pfannenstiel incision rather than the incision of upper

midline for the extracorporeal stapling anastomosis, the anastomotic technique can lessen postoperative discomfort and the danger of incisional hernia. Additionally, according to some publications, the number of lymph nodes that can be recovered after a robotic colectomy of right-side is much higher, suggesting that this procedure may have an advantage in terms of oncologic outcomes. [12] Since da Vinci® Xi was released, using this robotic system for the colonic surgery have gotten simpler. Da Vinci® Xi system uses a platform that is considerably different from the current S or Si systems. The arm of robot is narrower and vertically longer than the previous models, which allows for a greater range of movement from left-to-right, among other differences. Consequently, compared to earlier models, which were focused on intensive movement in a small space, it is better suited for surgery on a vast region. This is possible to span surgical range of the numerous quadrants even when used in rectal surgery without de-docking and re-docking. [9] With the advancement of technology, colon cancer surgery with the robotic system has become simpler.

Technically demanding procedures

In relation to the treatment for metastasis, the LPLN (lateral pelvic lymph node) in the rectal cancer is lesion that is the subject of numerous discussions. According to findings from Japan, up to 16–25% of individuals with low rectal cancer with a T2 or higher have developed metastases to the LPLN.[24] In Japan, LPLN was classified as the regional lymph node, and the routine LPND was advised in the rectal cancer cases with a T3 or above tumour whose bottom border is placed below the peritoneal reflection. [24] In contrast, radiotherapy is used in the West to treat LPLN metastases instead of surgery. Despite advancements in radiotherapy, some individuals eventually have these LPNDs because to recurrence or after preoperative treatment. This is neither technically simple for completion of dissection while preventing harm to important tissues including internal iliac artery, obturator nerve, and ureter because LPND is not yet a common surgical procedure in the West. Additionally, it is more challenging to carry out this treatment using a laparoscopic tool that has limited range of motion, and the LPND of right-side is particularly challenging because of approach of surgeon. The use of the robotic system for the LPND is quite beneficial.[24] While limiting damage to important structures, a steady viewing field, counter-traction, and articulating tools allow for effective left- and right-sided lymph node dissection (LPND). For example, employing a trans-anal injection of indocyanine green (ICG) having near infrared fluorescence feature included into robotic system can make it easier to find the metastatic lymph nodes. Future robotic LPND outcomes monitoring will need to include both the long- and short-term oncologic outcomes.[24]

The robotic equipment makes it simpler to carry out difficult procedures in addition to LPND. Because it necessitates the dissection to extremely deep pelvis and demands careful, effective traction & exceptional eyesight to precisely identify anatomical features, intersphincteric resection (ISR), which is being explored for treatment of the very lower rectal cancer, is a challenging procedure. In particular, sticking to oncological guidelines when performing ISR by laparoscopy is technically exceedingly challenging. ISR could be carried out more simply with the help of robot, and according to various studies, procedure takes about the same amount of time as for surgery laparoscopically. In contrast, laparoscopic surgery takes less time than robotic surgery to treat rectal cancer overall. [24] Since these treatments were more challenging technically than the traditional TME, such as the multi-visceral excision of the advanced pelvic malignancies or the transanal TME, the benefits of robotic systems are maximised. Additionally, robotic ISR produces oncologic outcomes that are comparable to those of traditional laparoscopic or open surgery.[24] The Korean group published a multi-center study where overall three-year the local recurrence and the three-year of the disease-free survival are comparable for both surgical procedures. Our institution is now conducting a survival analysis, and the 3-year local recurrence rates for laparoscopic and robotic groups were both 10% and 13%, respectively. Due to the benefits of the minimally invasive surgery

without a stoma permanently and preservation of oncologic principle, robotic surgery may therefore the best surgical option for the patients having extremely lower rectal cancer.

New surgical robot systems

Few new surgical robotic systems are either being developed or had just released. The most recent, da Vinci® SP, has a single port that can hold one camera and three instruments. Procedures employing da Vinci® SP are substantially most stable and ergonomic than the traditional laparoscopic single-port surgery because each tool includes a wrist and an elbow. Da Vinci® SP can perform large surgeries, but its utility is still restricted because to its short traction distance, insufficient grasping force, and constrained degree of articulation compared to prior iterations. Most accounts of its utilisation are to procedures like prostatectomy or cholecystectomy, which can be done in a small space or with little traction.[25]

Figure 4. da Vinci® new surgical robot systems

Da Vinci® SP has been used in trans-anal TME and trans-anal minimally invasive surgery (TAMIS), while there have been few studies reporting its usage in colorectal surgery.[25] Da Vinci® SP may be best platform for applying NOTES given that the single-port surgery was founded on idea of the NOTES, and trans-anal surgery may be the best application for da Vinci® SP. In addition to such situations, we also use da Vinci® SP during major colectomy. We confirmed that the colectomy of right-side was possible with the suprapubic technique utilising da Vinci® SP in real patient instances having the earlier colon cancer or the advanced adenoma, and we are almost ready to share these data. We anticipate that this method will make a colectomy of right-side possible with a little incision and discomfort.

Other businesses are creating surgical robot systems. Six arms are built into the operating table of a new device called Ottava® to give surgeons additional control and flexibility. Within a few years, this new robot system will go through the validation and verification before being included in the clinical trials. A second novel surgical robot has combines imaging data with robot system for usage in conjunction with a clinical decision-support programme that is guided by surgical planning utilising artificial intelligence

(AI). This system will offer cloud-connected surgical video management when used in conjunction with a computer. Numerous further surgical robot systems, likewise tiny in-vivo robotic assistant or surgeon cameras operated by eye sensors, or haptic feedback, are now being developed (MIRA). Patients and surgeons will have more options and advantages as a result of these new technology.

CONCLUSION

Robotic surgery is becoming more and more common in treatment of the rectal cancer in field of the colorectal cancer. In contrast to original predictions, it failed to provide distinct quantitative improvements over laparoscopy in a number of short- and long-term investigations. However, it might be difficult to convey through measurable outcomes the benefits of robotic technology that surgeons perceive during complex surgeries. Robotic surgery can broaden the scope of minimally invasive procedures, making it a useful choice for treating colorectal cancer. In order to demonstrate these advantages objectively, continued work and research will be required.

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