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The Current Scope of Robotic Surgery in Colorectal Cancer

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Abstract

Robotic surgical systems have dramatically overcome laparoscopic surgery limitation, which show great touch on the scope of minimum invasive surgery. Robotic surgery has great influence on the surgeon performance and comfort during surgery, in which can handle the procedure with lesser extent of fatigability. Implantation of three-dimension magnified stable camera, articulated instruments, and ability to omit physiologic tremors help to extent scope of dexterity and ergonomics. Therefore, robotic platforms could potentially assist to improve overall patient outcome with highly sophisticated technique. However, the success of Robotic oncological outcome has not addressed well in the literature with on-going controversies. In order to weight and balance the advantages and the cost of robotic surgery, further resources are required to validate the true value of Robotic surgery in colorectal field. The aim of this review is to summarize the current evidence of robotic surgery in clinical and oncological outcomes in colorectal cancer.

Keywords: Review; Robotic surgery; Colorectal surgery; Current state

Introduction

Laparoscopic colorectal surgery for cancer has gained popularity and widely used as the most widespread approach for colorectal surgery with improved short outcome and comparable long-term oncologic outcomes to those of open surgery [1]. Laparoscopic surgery has several limitation and barriers including hand tremors, loss of human wrist's motion, and loss of three-dimensional vision, the need to use longer instruments, loss of dexterity, long steep learning curve and surgeon exhaustion [2,3]. Robotic surgery has emerged into the territory of gastrointestinal surgery to highlight its additional features that could mitigate the obstacles of laparoscopic surgery in colorectal cancer. This new advent of robotic colorectal surgery had started first in 2001, which had been remarkable with lots of promises in the colorectal field [4,5]. Currently, the only commercially available robotic platform, the da Vinci system (Intuitive Surgical, Inc., Sunnyvale, CA, USA), has many advantages such as three-dimensional vision, 7° of wrist-like motion, tremor filtering, motion scaling, better ergonomics, and less fatigue help to overcome laparoscopic limitations However, robotic colorectal surgery (RCS) has several drawbacks such as the lack of haptic sense, bulky robotic cart, higher cost, potential risk of external collisions, the limited range of movement of the robotic arms and increased operative time [6].

Furthermore, oncological outcome are almost likewise to laparoscopic surgery, beside the possibility of faster urinary and functional outcome in robotic surgery. More controversial, however, is to prove the superiority of robotic surgery in colorectal cancer compared to laparoscopic technique in terms of oncologic outcome. Thus this review is to summarize the comprehensive evidences of the current state of robotic surgery and to assess safety, feasibility, and outcomes of this newly emerging technology of robotic surgery.

Techniques of Robotic Surgery in Rectal Cancer

There are different techniques described in the literature with various robotic sets up. We experienced rectal surgery on the most recent versions of robotic machine Da Vinci Xi and Si system as described in the next paragraph.

Da Vinci si system

Setting up Da Vinci si system: There are several techniques in setting robotic system up, which are single, dual docking, hybrid technique and single port robotic surgery. Recently, Bae et al. [7] described the two stage robotic dual docking technique in 61 patients with left sided colon cancer, succeeded to mobilize splenic flexure fully in all patients without the need for conversion with an efficient oncological outcome. However, this technique might end with longer operating time [8], that compensated by upgrade learning curve, knowledge and robotic penetration in the medical field.

To shorten our journey in robotic surgery, we follow a single docking technique in our institute. This technique aims to bypass the need of frequent docking of the robotic machine with faster preparation, especially if robotic system had installed in experience hands [9] which suggested first by Hellan et al. [10]. The drawback of singles docking technique is the possibility of collision, which could be avoided by following certain pathway and measure that we experience in our institute. Ports placement and patient position discussed in details in our previous report [11], as we experience this technique without troublesome external collisions as illustrated in Figure 2. However, the disturbance of workflow by external collision during splenic flexure mobilization is a common obstacle in the beginner's hands. Well skillful surgeons and selecting the proper port site are the primary concern to avoid such obstacles. For better illustration, procedure videos available in the following attached link; (http://www.davincisurgerycommunity.com/playvideo?type=AM&fileEntryId=2357671).

Hybrid technique: Hybrid technique is a technique that required

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two minimums invasive systems in a single patient, thus surgeon have to be adapted and skillful in both laparoscopic and robotic systems. The first part of procedure starts with laparoscopic system to facilitate splenic flexure mobilization as well as mobilization of left colon and IMA ligation branches. Then robotic system comes afterword to pelvic side, as the main advantages maximize during rectal dissection by robotic system utilization [11]. Despite higher cost of the procedure due to using laparoscopic instruments on top of robotic system cost, might help beginners to fasten up the procedure, particularly splenic flexure part. Moreover, in order to compensate the cost of the procedure, improve skills in laparoscopic surgery help to carry out the first stage of the procedure faster, in which you would be able to cut down operating time as much as possible.

We recommend fully understanding each technique to handle each case by case accordingly. For example; if you need to take down splenic flexure in fatty mesentery will be easier in Hybrid technique. In addition, it takes good place for training improvement in initial surgeon series in robotic surgery.

Single port robotic surgery: Efforts are challenging to further concentrate on the cosmetic outcome of robotic surgery as well as reduce port-related morbidities. Single incision laparoscopic surgery (SILS) was first described for laparoscopic appendectomy [12] then successfully implanted in colon procedure [13]. First record of SILS right colectomy was in 2008 [14,15] with several limitations such as instrument angulations, working in a different direction side with narrow field vision and encountering dissection difficulty due to axis orientation. Robotic surgery has emerged to overcome all of these complexities in SILS techniques, beside cosmetic outcome ensured, optimizing visualization and handling tissue in the right track which help to gain adequate oncological specimen quality, less postoperative pain and shorter operation time. Single robotic port surgery has described recently in details by Bae et al. [16] and Spinoglio et al. [17] in left and right colon procedures respectively. we experience single port robotic surgery with great success and feasibility. It maintained adequate surgical outcome without a record of conversion to open surgery in our practice. Interestingly, Bae et al. [16], studied outcome of 11 patients with left colon cancer, operated by single port robotic surgery, shown le ss operative time compared to other robotic techniques. Single port robotic surgeries facilitate adequate dissection in an excellent cosmetic outcome without encountering struggles reported in SILS technique.

Da Vinci xi System: Several limitations in robotic Si version in colorectal surgery, for instance: inability to perform multi-quadrant operation, fixed heavy arms, need of re-docking and risk of collisions which disrupt working channel and might extent operative time further. Recently, a new innovation of Da Vinci Xi has admitted in the market, which contributed to overcome obstacles and limitations of the previous platform. Rectal cancer surgery is a good example to look at how Da Vinci Xi platform works in multi-quadrant areas smoothly, however potential risk of collision is possible, since totally robotic pelvic procedure hasn't standardized in Da Vinci Xi yet.

Moreover, Da Vinci Xi docking is simple, designed slim and flexible with movable top roof, without draping. New platform of Da Vinci Xi implanted with a light camera scope, has autofocus, camera lens at the tip of the scope and lastly, camera scope can be placed in any of robotic arms freely. Interestingly, Universal Port Placement Guidelines Manual in which a surgeon can follow the recommended trocar position depending on the type of procedure. Nevertheless, this guideline has not provided with multi-quadrant targets approach, which is required in rectal surgery to approach splenic flexure and pelvic at the same operation in a single docking technique.

Luca Morelli et al. [18], follow Left Lower Abdominal Procedures Universal Port Placement Guidelines from intuitive surgery, he stated the ability of single docking totally robotic surgery with dual target approach. In our experience, we follow keywords to avoid troublesome during the operation. First, linear configuration of part site insertion with 2-3 cm distances from umbilicus as demonstrated in Figure 3. Secondly, targeting the new platform of Da Vinci Xi at the sigmoid colon, in which we able to mobilize splenic flexure completely as well as dissection down to the pelvic floor easily without changing patient position or altering platform target. Further experience is strongly recommended to standardize the technique and to appreciate and clarify the role of Da Vinci Xi in rectal surgery and its real advantages over the Da Vinci Si system.

Application of Robotic Surgery in Rectal Cancer

Total mesorectal excision [TME]

TME procedure is the gold standard for rectal cancer surgery, in order to preserve pelvic plexus and to avoid presacral bleeding, we should optimize visual accuracy to stay in avascular plane along the fascia propria of the rectum without causing injury to adjacent structures [19,20]. New mission of robotic machine has come to approve its safety and feasibility as it is illustrated by kim et al. [9]. Since 2007, we performed TME using robotic system with comparative oncological outcome to laparoscopic surgery. Few keywords to maintain integrity and quality of TME in several steps:

1. Caution dissection at inferior mesenteric artery (IMA) root, where superior hypogastric plexus network lied there. If injured, might end with retrograde ejaculation

2. Mobilization of the rectosigmoid colon from the gonadal vessels and ureters, the hypogastric nerves are at risk at this level. Therefore, the correct surgical plane should be between the rectal proper fascia and prehypogastric nerve fascia

3. Caution at inferior mesenteric vain (IMV) ligation, as collateral vessel crossing IMV root, if injured, could contribute in blood supply cut down then increase risk of anastomotic leakage

4. Avoid blunt dissection in the posterior pelvic side, particularly at recto-sacral fascia to avoid fascia avulsions and presacral bleeding

5. Anterior liner incision at the peritoneum reflection with intensive caution to 3 important structure, which are seminal vesicles in men or vaginal wall in women, watch neurovascular bundles from the pelvic plexus run along the tip of the seminal vesicle (2 o'clock and 10 o'clock directions), [11] and lastly, as deeper you proceed with anterior dissection, as better recognition of Denonviliers fascia will be, where posterior dissection is recommended to avoid troublesome bleeding and nerves damage, unless if the tumor located anteriorly or threating up front structure, then consider taken down Denonviliers fascia with the specimen

6. Final step is to keep circumferential dissection all around the rectum to avoid coning of the mesorectum at the pelvic floor

Cho et al. [21] compared an overall outcome between Robotic TME (R-TME) and laparoscopic TME (L-TME), illustrated similar pathological and oncological outcome, beside faster voiding function in R-TME group. In addition, Petriti et al. [22] recorded 0% conversion rate in R-TME compared to 19% in L-TME. Furthermore, Saklani et al. [23] conducted a comparative retrospective study in 138 patients operated by R-TME and L-TME, found less conversion rate in robotic arm rated at 1.4% vs. 6.3% than laparoscopic arm but didn't reach statistical significant (P=0.183), while long and short term outcome were similar in both groups (Table 1).

The inter-sphincteric resection (ISR)

It is an extended procedure to TME steps with further dissection on the pelvic floor. This procedure required knowledge of the pelvic floor anatomy and fusion lines between the muscles and rectum. Adequate skills required to identify ISR plane starting from abdominal phase between the pubococcygeus or puborectalis and internal anal sphincter (IAS) muscle [24]. Secondly, transanal phase which is started by tumor localization to decide how extent you would be in surgery. As ISR is classified to partial, subtotal, and total ISR, according to the level of incision placement at the white line of Hilton, as above the dentate line, between the dentate line and the inter-sphincteric groove and total excision of the IAS respectively [6]. Excision of the deep external anal sphincter (EAS) muscles could be performed whenever tumor infiltration suspected. Lastly, and before coloanal anastomosis, we ensured four important parameters to avoid complications in our practice, which are obtain healthy bowel, maintain free tension anastomosis, reassert vascularity status and to maintain adequate tension in order to prevent mucosal prolapse later on as demonstrated in Figure 1.

Apparently robotic surgery has potential advantages in better identification of pelvic floor structures through three dimensions camera, proper magnification, and camera controlled by surgeon and robotic function to eliminate physiological tremors. A recent muticentric study conducted by Park et al. [25], compared robotic-ISR to L-ISR in 334 patients, demonstrated less conversion rate, reduced need of long stay stoma, less hospital stay, less complications than L-ISR beside higher cost and longer operation time in R-ISR that required further evidence to justify high cost in robotic surgery.

Abdominoperineal resection (APR)

It is procedure that follows TME techniques with perineum excision as described by Bae et al. [26] using robotic surgery. In our institute, we consider levator eni muscle excision if invaded or threaten by the tumor in order to minimize risk of positive circumferential resection margin (CRM + ve). Recently Kim et al. [27] compared 48 patients underwent APR either by Robotic or laparoscopic technique, which showed larger number of lymph nodes retrieved in robotic arm than laparoscopic APR (P=0.035), in addition, four CRM+ recorded in open APR compared to robotic one. Interestingly they reported the mean depth of CRM was more than three times greater in the robotic than in the open arm (P=0.017) and higher incidence of non-cylindrical resection in open arm. Robotic system can visualize deeper structures in the pelvis without troublesome obstacles in laparoscopic surgery. In turn, robotic surgery could maintain higher quality of specimen and oncological outcome anticipated in near future.

Hemi-elevator excision

Our experience in robotic procedure explained in details by SF AlAsari et al. [28]. Certainly, we consider hemi- elevator excision procedure if we suspect tumor invasion at the level of levator eni.

Authors	Country	Study Type	Type of Surgery	Study Sample	Conversion Rate	Leak Rate	Operation Time (min)	LOS
Cho et al. [21]	South Korea	Retrospective PSM	L-TME vs. R-TME	556 patients	S	10.8%vs10.4%, (P=1.000)	Longer in R-TME**	S
D'Annibale et al. [74]	Italy	Retrospective	R-TME vs. L-TME In rectal caner	100 patients	Lower in R-TME (P= 0.011).	S	S	--
Baik et al. [40]	South Korea	RCT	R-TSME vs. L-TSME	36 patient	S	--	13 min longer in R-TME (217 vs. 204.3)	Significantly shorter in RCS
Baik et al. [44]	South Korea	RCT	R-LAR vs. L-LAR	113 patients	Less in R-LAR (0 vs. 10.5%) (P = 0.013)	--	R-LAR favor	Shorter in RCS (5.7 ± 1.1 vs. 7.6 ± 3.0 d, P = 0.001)

1a: Short-term outcome in low rectal cancer surgery.

Author	Country	Study Type	Type of Surgery	Study Sample	Conversion Rate	Leak Rate	Operation Time
Mak et al. [56]	China				(0% to 8.0%) in RS Vs. (1.8% to 22%) in LS (P>0.05)	6.4% in RS vs. 7.4% in LS	
Saklani et al. [23]	South Korea	Retrospective	Proctectomy*	138 Patients	Favor Robotic 6.3% vs.1.4% (P=0.183)	S	Longer in Robotic (p=0.033)
Kang et al. [60]	South Korea	Retrospective PSM	Proctectomy*	495 Patients	--	(P=0.126)	Longer in Robotic (P=0.012)
Memon et al. [97]	Australia	Meta-analysis	Proctectomy*	73 articles	Risk reduction of 7% favoring RCS	S	43 min more in RCS
Patriti A et al. [22]	Italy	RCT	Proctectomy*	66 Patients	Favor Robotic (0 vs. 19%) P<0.05	Favor Robotic (2.7% vs. 6.8%) P>0.05	Longer in Robotic P<0.05

1b: Short-term outcome in proctectomy surgery.

Abbreviations: OT: operation time, LOS: length of stay, EBL: estimated blood loss, S: similar, LCS: laparoscopic colorectal surgery, RCS: robotic colorectal surgery, N: patients number, Lap: laparoscopic surgery, d:day, TME: total mesorectal excision, LAR: low anterior resection, CA: coloanal anastomosis, APR: abdominopreneal resection. Proctectomy (Rectal cancer operations) (TME, APR, LAR,CA). PSM: propensity score match study. Longer operation time (361.6_91.9 vs 272.4_83.8 min) P<0.001).

Table 1: Short-term outcome in robotic vs. laparoscopic surgery in rectal cancer.

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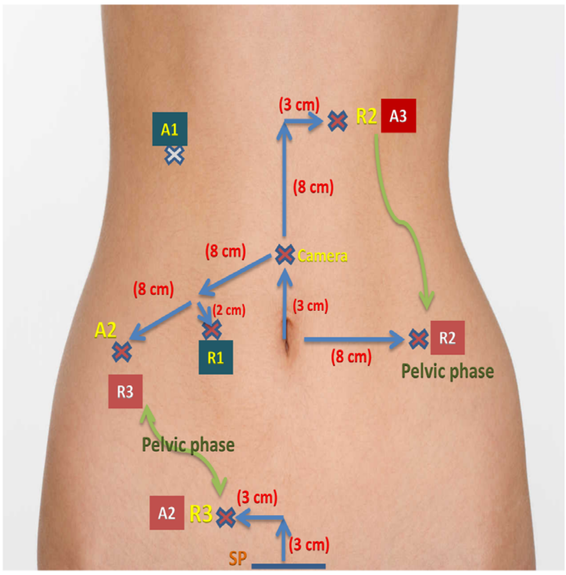
Figure 1: Illustration of Extensive Perianal Procedure with Sphincter Preserving Surgery,

A: Inter-sphincter Resection of Very Low Rectal Tumor, B: Hemi-elevator Excision in Low Rectal Tumor Invading Levator eni Muscle.



Robotic single docking ports placement in the abdomen and pelvic stages for rectal cancer procedure. **In the abdomen phase (yellow mark);** A: Assistance port located in the mid-clavicle line 8 – 10cm away from other port, at least 2 cm away from bone, Camera port located at 3 cm superior tothe umbilicus, R1: robotic arm No.1 placed at 8 cm from camera port, R2: robotic arm No.2 incised at 8 cm from camera port then 3 cm laterally away from subcostal bone, R3: robotic arm No.3 placed at 3cm superior and laterally to symphysis pubisbone (SP) as illustrated. **In the pelvic phase (red mark);** 2 arms move only as shown in green arrow, otherwise resemble to abdominal phase; R3: moved to 16 cm from camera port toward anterior superior iliac spine in exchange with assistance port No2, R2: moved to 8 cm laterally from umbilicus as shown in the picture, A3: 3rd assistance port for rectum retraction during pelvic phase.

Figure 2: Illustration of Ports Site Insertion in Robotic Da Vinci Si System, Single Docking Technique in Rectal Surgery.

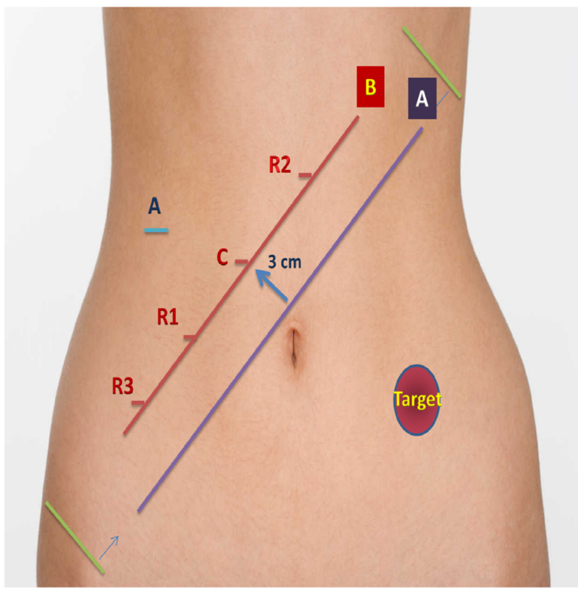
Robotic surgery has great help to visualize tumor location and relation to adjacent muscles on the pelvic floor. Since advent of robotic system in our institute, we successfully divide levator eni muscle through abdominal phase, which help to avoid blunt or blind dissection in perineum phase. Nevertheless, lack of comparative study or RCT trial to approve the effectiveness and superiority of robotic hemi-elevator excision on laparoscopic surgery, has made robotic surgery less popular, along with higher cost and longer operating time with similar outcome reported in similar procedures.

Robotic-assisted lateral pelvic lymph node dissection [LPLND]

We have successfully performed robotic LPLND in our practice with tremendous outcome [29] shortly; Patients placed in the Trendelenberg position at 30° and tilted right side down at an angle of 10°-15°. LPND performed after TME had completed, thus port placement would be as it's in rectal surgery without additional port requirement. The first step in LPND was dissection and isolation of the ureters with a silastic loop. Lymph nodes and fatty tissue were dissected from the bifurcation of the aorta extending down to internal iliac vessel to identify obturator canal, lymphatic tissue cleared at a safe distance from the lateral side of the pelvic plexus, obturator nerve and vessels were identified medial to the external iliac vein and lateral to the superior vesical artery. The obturator lymph nodes were resected leaving the obturator nerve and vessel in the obturator fossa preserved.

Whether robotic surgery has succeeded to approve its theory over laparoscopic surgery or not? Yet lack of supportive evidence to answer this question in colorectal field. However few studies published with optimistic vision in minimum invasive surgery. As in Bae et al. [29], compared 21 patients underwent LPLN dissection by minimum invasive technique [robotic and laparoscopic] compared to open way, revealed higher success in minimum invasive approach, whereas no trials in robotic vs. laparoscopic approach in LPLN dissection.

Robotic single docking ports placement in the abdomen and pelvic stages for rectal cancer procedure. In the abdomen phase [yellow mark]; A: Assistance port located in the mid-clavicle line 8-10 cm away from other port, at least 2 cm away from bone, Camera port located at 3 cm superior to the umbilicus, R1: robotic arm No.1 placed at 8 cm from camera port, R2: robotic arm No.2 incised at 8 cm from camera



Procedure: started by drawing 2 imaginary lines, first line between femoral head and 8th rib, marked as (A) line. Second imaginary line, marked as (B), is parallel to the (A) line with 3 cm apart from (A) line. Camera (c) port is 3 cm away and perpendicular from (A) line. R1 (robotic arm 1), R2 (robotic arm 2), R3 (robotic arm 3) are located at the (B) line with 8 cm apart from each other. A (assistance port), located at the middle abdominal quadrant with at least 6-8 cm from robotic arms. Target point is where to point out and target Da Vinci Xi system toward it, in which the system will recognize the target to configure the shape of the robotic arm according to the target point.

Figure 3: Port Site Insertion in Rectal Surgery for DaVinci Xi System.

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port then 3 cm laterally away from subcostal bone, R3: robotic arm No.3 placed at 3 cm superior and laterally to symphysis pubis bone [SP] as illustrated. In the pelvic phase [red mark]; 2 arms move only as shown in green arrow, otherwise resemble to abdominal phase; R3: moved to 16 cm from camera port toward anterior superior iliac spine in exchange with assistance port No2, R2: moved to 8 cm laterally from umbilicus as shown in the picture, A3: 3rd assistance port for rectum retraction during pelvic phase.

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Critical Landmark to Prevent Autonomic Nerves Plexus Damages

Sympathatic nerves plexus in pelvic cavity

Originated tenth thoracic (T10) to the second lumbar (L2) spinal segments, T12 -L2, or L1-L3 [30-32]. The course of these nerves branches down into 3 divisions in the pelvic cavity, they are bilateral hypogastric nerves, sacral sympathetic chain, and superior rectal plexus, branched from the inferior mesenteric plexus. The superior rectal plexus accompanies the superior rectal artery is sacrificed during IMA dissection. The first and foremost important nerve to save is superior hypogastric plexus, which has direct effect on urinary and sexual function [33]. Kinugasa et al. emphasized the presence of hypogastric fascia that cover hypogastric nerve (HGN) as a sandwich layers, by two fascial structures; the ventral fascia seemed to correspond to the mesorectal fascia, whereas the dorsal fascia corresponded to the presacral fascia. These fasciae or the HGN sheaths extended laterally along the ventral aspects of the great vessels and associated lymph follicles. The ventral fascia is, to some extent, fused with the mesocolon on the left side of the body. In addition, he notified the lateral continuation of these two fascia's to sandwich the left ureter, but not the right ureter, due to modifications by the left-sided fusion fascia. He made an effort to discover fascia embryology and morphology in order to preserve HGN. The paired hypogastric nerves run 1-2 cm medial to the ureters and enter the pelvis by crossing the common iliac arteries at the level of the first sacrum and then, run along the posterolateral wall of the pelvis [34]. These nerves located between prehypogastric nerve fascia and parietal presacral fascia [35], where you keep your surgical dissection between prehypogastric fascia and the rectal proper fascia to prevent damage of these nerves. Injury to the unilateral hypogastric nerve causes retrograde ejaculation, and bilateral damage may result in urinary incontinence, retrograde ejaculation in men, and decreased orgasm in women [36].

Parasympathetic nerves in the pelvic cavity

Raised from 2nd to 4th sacral spinal nerves, referred as the pelvic splanchnic nerves or nervi erigentes. Nervi erigentes meet hypogatric nerve to form pelvic plexus at the anterolateral side of the pelvic. The unique landmark to identify these plexus is the tip of seminal vesicles bilaterally [37]. Injury to the pelvic plexus may cause voiding disorder, erection, ejaculation, or lubrication dysfunction. The branching and confluence pattern of the inferior hypogastric nerve, pelvic plexus, and neurovascular bundles form a 'Y' or 'T' shape [38].

Neuro-vascular bundles key point

Originated from the pelvic plexus and descend to the urogenital organ at the lateral corner of the seminal vesicle in the 2 o'clock and 10 o'clock directions. Injury to the neurovascular bundles may cause erection, ejaculation, or lubrication dysfunction.

Robotic Surgery Outcome

Short-term outcome

Operating time: Majority of recent robotic studies demonstrated longer operative time in robotic colorectal surgery (RCS) groups compared to laparoscopic colorectal surgery (LCS) [39]. Hybrid technique targeted to reduce robotic operating time and to compensate the early training phase in robotic surgery, however, cost might be raised without proper justification till now. Moreover, hybrid technique can jeopardize the benefit of robotic system in visualizing and preserving autonomic nerves at the IMA root, which can misinterpret outcome of robotic hybrid surgery in rectal cancer. In the other hand, several reports illustrated similar operative time between RCS and LCS regardless the technique or procedure [22,40]. However, lack of strong comparative evidence between different type of robotic technique and docking including operative time, short and long term to add further maturity for each robotic technique in different field of surgery.

Randomized clinical trial comparing robotic to laparoscopic TME surgery showed minimum longer operating time in robotic side [40], Likewise in Trinch et al. [41] showed only 38.4 min longer operating time in RCS compared to LCS. A recent meta-analysis of 4 randomized controlled trial [42], compared short outcome of RCS to LCS in colorectal cancer, showed RCS has a tendency to take longer operating time than LCS, but this difference wasn't statistical significant (P=0.06). As the surgeon's robotic experience increases, the techniques improved and the operation times will be reduced consequently. In addition, we have to consider the unequal comparison between robotic and laparoscopic operating time, since the former has gained popularity among the medical stuff and get used to its set up compared to early experience of robotic machine that contributed in longer operating hours [43] as demonstrated in Table 1. The operating time still represents an obstacle of robotic surgery in early stage of robotic training; however, this might be overcome with increased experience and knowledge of the robotic installations.

Estimated blood loss: EBL ranges between 90 ml and 320 ml for LCS and between 20 ml and 486 ml for RCS according to a recently published review [44]. Liao et al. [42] estimated EBL was significantly lower in RCS compared to LCS group that may significantly reduce the probability of transfusion and might prevent the recurrence of cancer group. Patriti et al. [22] and Several other studies showed resemble or favor at bleeding control in RCS as demonstrated in Table 1. Surprisingly, patients who receive more perioperative transfused blood are at greater risk for cancer recurrence [45] which emphasize to closely monitor potential area of bleeding and utilize the proper device. Dexterity and ergonomic of Da Vinci system might help to reduce bleeding rate, particularly in those whom bleeding tendency is the highest where robot can visualize minute bleeding points and assist to control it then a potential to reduce local recurrence afterwards in the future.

Intraoperative conversion to open: Conversion rates ranged from

1% to 7.3% in robotic rectal procedures [46], which is way less when compared to LCS in the CLASSIC trial which was rated at 29% [2] and 17% in COLORII [47]. Liao et al. [42] in a recent meta-analysis, revealed that the conversion rate was significantly lower in the RCS group than in the LCS group [P=0.04]. Moreover, Tam et al. [48] demonstrated conversion rate in favor of RCS (7.8 vs. 21.2%), (p<0.001) (Table 1).

Conversion rate is paramount valuable factor in surgical quality. Lower conversion rates associated with fewer postoperative complications [2], less hospital stay reduce total hospital charges, and decrease morbidity and mortality [49]. A recent systemic review [8] demonstrated 2.8% conversion rate in robotic surgery and illustrated reasons for conversion included obesity with heavy mesentery, inability to identify important vascular structures, vascular injury, adhesions, and narrow pelvis, technical difficulties that included stapler misfiring, inappropriate robotic arm placement, as well as robotic malfunction. Thus, dramatic reduction in conversion rate is one of key benefits of robotic system. Therefore, robotic surgery may be indicated in patients with previous abdominal surgery, lower rectal cancers and previous chemo-radiotherapy [46].

Duration of hospitalization: Reduction of hospital stay will be directly impact on the patient's fast recovery, return to normal activity and possible justification of cost effectiveness of robotic surgery. Indeed, length of stay recorded in meta-analysis and several trial showed shorter length of stay in RCS than LCS group, except in patriti A et al. [22] reported a longer hospital stay in robotic group compared to laparoscopic surgery as shown in Table 1.

Bowel function recovery: Defined as first flatus after surgery or a number of days to start peristalsis, which had defined by Park [50], and Baik et al. [40] respectively. Baik et al. [44], found quicker return of bowel function in RCS (4.7 ± 1.1 vs. 5.5 ± 1.5 days in LCS, (P=0.008). In addition Liao et al. [42] revealed that RCS group exhibited shorter times to bowel recovery than LCS group (P=0.008). Patel et al. [51] commented that RCS technique might resulted in reduced trauma and subsequent less postoperative pain, leading to earlier bowel return and discharge home earlier than LCS. These all can be used as evidences for the feasibility and safety of RCS in colorectal field, in addition to shorter LOS and faster recovery which could interpreted as a source of cost effectiveness of RCS in the field of colorectal surgery.

Pathological finding: The integrity of the mesorectum envelope, clear circumferential resection margin (CRM) and adequate distal resection margin [DRM] are important oncological and surgical end points. CRM<1 mm is predictive of an increased risk of distant metastases and shorter survival, whereas CRM<2 mm is a risk for increased local recurrence [52,53]. Recent studies suggested DRM of at least 2 cm is a therapeutic goal [54]. Baik [38] and Park et al., [48] reported proximal and distal resection margin indices were similar in both RCS and LCS (P>0.05). A meta-analysis [42] showed equivalent pathological outcome in both arms. Saklani et al. [23], found higher incidence of CRM+ in robotic group compared to laparoscopic, however it wasn't significant (3.4% vs. 1.6%; P=0.384). Throughout several studies, number of harvested lymph nodes ranged from (10.3-20) in robotic group compared to (11.2-21) lymph nodes in the laparoscopic group with no significant difference in both groups [46]. Take in consideration, the finding of discrepancies between RCS and LCS in the tumor level and depth, as lower tumor and advance cases had seen in robotic surgery, which might justify robotic surgery safety and feasibility without compromising oncological outcome despite the worse features of the tumor in RCS patients.

Furthermore, quality of the TME dissection is paramount, as a break in TME envelope would increase local and distant recurrence. Two comparative studies found robotic dissection is superior to LCS and may offer additional advantage in the future [47,55]. Baik et al. [40], prospective randomized study with 14.3 months follow up, found a significant different of mesorectal grade between RCS and LCS, rated at complete TME 52 vs. 43 patients respectively with (P=0.033), however no statistical significant difference shown in CRM, DRM or proximal resection margin [PRM] as shown in Table 2.

Robot-assisted surgery allowed us to achieve a complete and oncological adequate resection of the cancer with superior TME quality preferred in most of the studies, which in turn robotic TME could reduce, local recurrence and enhance overall.

Postoperative complications: In a recent systemic review found overall complication rates were similar between robotic and laparoscopic group in colorectal cancer [42,56]. Liao et al. [39] illustrated the complication rates were similar across studies, and there was no significant heterogeneity. Cho et al. [21] demonstrated comparative results of early and late complications of R-TME and L-TME group at 25.9% vs. 23.7% and 23.7% vs. 20.1% respectively

Articles	HLN	CRM	DRM	TME quality
Cho et al. [21]	**S*(P=**0.069)	S (4.7% vs. 5.0%) (P=1.000)	S	--
Mak et al. [56]	S**	S	S	Superior in RCS
Kang et al. [60]	S (Favor RS)	S (P=0.77)	S	RCS favor
Memon et al. [97]	S (P=0.94).		S (P=0.84) Except Patriti et al. who Reported a high standard deviation for LCS (7.2 cm)	
Baik et al. [44]	S	S	S	RCS>LCS
RCT	P=0.825	P=0.749	P=0.497	P=0.033
Baik et al. [40]	Favor RCS	S	Favor RCS	Favor RS (17 vs.13 cTME)
D'Annibale et al. [74]	Favor RCS P=0.053	Favor RCS P=0.022	S P=0.908	--

Abbreviations: HLN: Harvested lymph nodes, CRM: Circumferential resection margin, DRM: Distal resection margin, TME: Total mesorectal excision, RCS: Robotic colorectal surgery, LCS: laparoscopic colorectal surgery, S: similar. cTME: complete TME.* HLN in L-TME vs R-TME: 16.2_8.1 nodes vs 15.0_8.1 nodes. ** HLN (10.3 to 20) in RCS vs. (11.2 to 21) in LCS.

Table 2: Pathological outcome of robotic vs. laparoscopic surgery in rectal cancer

P > 0.05. Interestingly, Saklani et al. [23] included 138 patients in a comparative study between robotic and laparoscopic rectal cancer surgery after long course chemoradiotherapy, revealed higher complication rate in laparoscopic procedures anastomotic leaks and pelvic abscess but didn't reach statistical significant. Moreover, most of the studies reported favorable or similar complications rate in robotic than laparoscopic surgery as shown in Table 1.

Hence then, advantages of robotic system might be associated with lower postoperative complication rates that justify robot cost effectiveness in the future.

Anastomotic leakage: One of the most dreaded complications following rectal cancer surgery is anastomotic leak. Overall, the median anastomotic leakage reported at 7.6% (range, 1.8-13.5%) for RCS compared with a median anastomotic leakage was 7.3% (range, 2.4-11.2%) for LCS [46]. Cho et al. [21] reported similar anastomotic leakage as illustrated in Table 1. Surprisingly, a recent systemic review [24,35] reported a lower leakage rate in robotic ISR arm compared to laparoscopic surgery. In contrary Baek et al. [57] reported a leakage rate of 8.6% for the robotic procedures versus a rate of 2.9% for laparoscopic surgery with no statistical difference (p=0.62). Throughout review several articles, found robotic anastomotic leakage are either similar or lesser than laparoscopic surgery, which support feasibility and threshold toward lesser complication in robotic as shown in Table 1.

Long term outcome of robotic surgery: Recent emerge of robotic surgery in the field of colorectal surgery; long-term oncology outcome has not addressed well. Few studies reported their robotic surgery experience in colorectal field. Baek et al. [57] demonstrated a long-term oncologic outcomes of robotic TME for rectal cancer at 3-year overall and disease-free survival rates of 96.2% and 73.7%, respectively. Cho et al. [58] illustrated likewise results with comparable long term outcome between both groups, rates at 5-year overall survival, disease free survival, and local recurrence rates (93.1% vs. 92.2%, P.0.422; 79.6% vs. 81.8%, P.0.538; 3.9% vs. 5.9%, P.0.313, respectively).

Additionally Kwak et al. [59], showed no significant differences between robotic and laparoscopic-assisted group in terms of loco-regional recurrence, distant. Furthermore Kang et al. [60] found no difference in 2-year survival between robotic assisted group (83.5%), laparoscopy group (81.9%) and open surgery (79.7%) (P=0.855). Moreover, a comparative study by Lim et al. [61] between RCS of sigmoid resection and LCS in term of oncologic outcomes, showed a 3-year overall and disease-free survival rate at 92.1% versus 93.5% (P=0.735) and 89.2% versus 90.0%, respectively (P=0.873). Lastly baik et al. [40] found no different between RCS and LCS in term of local or systemic recurrence. Innovation of robotic surgical system technology is safe and effective to maintain and achieve a complete TME in a convenient way without compromising oncological outcome.

Rule of Robotic Surgery in Specific Field

Robotic inter-sphinectric resection [R-ISR] outcome

Since ISR introduced in colorectal field, APR has remarkably reduced, which has facilitated by robotic system through adequate sharp dissection and proper visualization of pelvic muscles and anatomical planes. Leong et al. [62], conducted a prospective study in robotic ISR outcome, stated complete resection (R0) achieved for (90%) of the study sample, acceptable hospital stay, adequate CRM achievement with no major consequences, apart from 10% anastomotic leak which had treated conservatively. Moreover, R-ISR morbidities were comparable to robotic or laparoscopic TME [57,63]. Park et al. [64] commented on the feasibility of R-ISR to achieve an adequate short and long-term outcome compared to laparascopic ISR, however operative intra-abdominal time was longer but perineal phase was significantly shorter in the R-ISR group than L-ISR.

Recently, retrospective study by Yoo et al. [65], compared R-ISR with L-ISR, demonstrated similar operative, oncological, and functional outcomes beside unfavorable tumor features in robotic arm. Lastly, there were no significant differences in the 3-year OS (88.5 vs. 95.2%; p=0.174), 3-year RFS (75.0 vs. 76.7%; p=0.946) [65]. Likewise in park et al. [25] reported a comparable oncological outcome to L-ISR apart from higher cost recorded in R- ISR group. Whereas baek et al. [66] showed similar surgical outcome in both groups but favor R-ISR in term of shorter hospital stay, lower conversion rate and higher level of comfort during surgery. In a recent prospective study by kim et al. [24] compared open ISR to R-ISR, revealed a Moderate to severe sexual dysfunction and greater fecal incontinent in open surgery, (p=0.023) and (p<0.05) respectively. Despite infancy stage of R-ISR, we could record few advantages of R-ISR over conventional methods, however further studies and longer follow up required evaluating the true value of Robotic surgery.

Is Robotic right colectomy outcome superior to laparoscopic surgery?

New innovation of robotic system in the field of colon cancer has gained popularity in the surgical field due to it is safety and feasibility in colorectal cancer, which was reported initially by weber et al. [5] in benign disease, then several reports published afterward [67]. Despite higher cost of robotic surgery, there are ongoing clinical trials to answer the actual oncological benefit of robotic surgery in colon cancer. Yet few studies have published to compare between robotic and laparoscopic right colectomy. A retrospective study by deSouza et al. [68] showed similar outcome in both approach, however higher cost and longer operation time recorded in robotic arm. Park et al. [50] showed similar results in both arms, but higher cost in robotic surgery, reached US $12 235 versus $10 320; (P=0.013) as shown in Table 3.

Interestingly Trastulli et al. [69] showed faster return of bowel function and shorter hospital stay in robotic surgery. In addition Lujan et al. [70] studied outcome of 47 patients underwent robotic and laparoscopic right colectomy retrospectively, found significant difference in blood loss, favoring robotic arm at range of 10-200 ml vs. 10-300 ml in laparoscopic arm, P=0.037), otherwise other parameters were equal. In 2015, a recent meta-analysis by Rondelli et al. [71], reviewed 8 studies comparing R-RC and L-RC, stated a significant lower incidence of intra-operative blood loss and faster bowel function in robotic arm, however longer operating time and higher cost found in robotic group, that explained by docking and reset robotic machine as well as considering early learning in intra-corporeal suturing that could affect the overall operative time. Morpurgo et al. [72] studied 48 patients R-RC and compared them to 48 L-RC, demonstrated several advantage of robotic over laparoscopic surgery which were faster bowel function (3.0-1.0 days vs. 4.0-1.2 days; P<0.05), shorter hospital stay (7.5-2.0 days vs. 9.0-3.2 days; P<0.05) respectively in additional to four anastomotic complications and four incisional hernias reported in L-RC and none in R-RC (P<0.05). These trials could potentially answer the inquired questions about robotic surgery, however further trials are required to weight and balanced the true advantages of robotic right colectomy in future.

Author	Country	Study Type	Type of Surgery	Study Sample	Conversion Rate	Leak Rate	Operation Time	Length of Stay
Rondelli et al. [71]	Italy	Meta-analysis and systemic review	R-RC vs. L-RC	8 Studies	S	S	--	S
Trastulli et al. [69]	Italy	Retrospective Multicentric study	R-RC vs. L-RC	236 Patients	S Favor R-RC	S P = 0.845	Longer in R-RC p<0.001	Shorter in R-RC P<0.001
Park et al. [50]	South Korea			71 Patients	S	1 case in R-RHC	Longer in R-RC	S
		RCT	R-RC vs. L-RC				P<0.001	
deSouza et al. [68]	USA	Retrospective	R-RC vs. L-RC	175 Patients	S	No leak in both arms	Longer in R-RC Operative time (P=.001)	S

Abbreviation: R-RC: robotic right colectomy, L-RC: laparoscopic right colectomy, OT: operative time, S: similar

Table 3: Short-term outcomes of robotic right colectomy vs. laparoscopic surgery.

Author (Year)	County	Study type	Sample N.	Operation Time (Min).	Conversion	Complication	LOS (SD)	EBL (ml)
Spinoglio et al. [43]	Italy	Prospective In LC cancer	R – 10 L - 73	Longer in RLH P<0.00	S	S	S	S
Shin et al. [98]	South Korea	Retrospective in LC cancer	R – 7 L – 12	337 vs. 265	No conversion	--	1.7 vs. 2.1	106 vs. 167
				Long in RLH	1 case in LLC	Favor RLH	Favor RLH	S
Lim et al. [61]	South Korea	Retrospective in LC cancer	R - 34 L-146	P = 0.016	No conversion in RLC	(5.9% vs. 10.3%) p=0.281		P=0.546
Casillas et al. [73]	USA	Prospective in colorectal procedure	R – 68 L - 82	188 vs. 109	Favor RLH (5.8% vs. 10.9%)	Favor RLH 11.7% vs. 20.7%)	Favor RLH 3.6d vs.6.5d	Favor RLH 89 vs.110

Abbreviation: R: robotic, L: laparoscopic, OR: operation room, SD: standard deviation, ml: milliliter, RLH: robotic left colectomy. LC: left colon, S: similar

Table 4: Short-term outcome of robotic left colectomy vs. laparoscopic surgery.

Is Robotic left colectomy outcome superior to laparoscopic surgery?

Multiple reports have reasserted the feasibility and safety of robotic left colectomy [57]. Few articles published in robotic left colectomy (R-LC) and compared to laparoscopic left colectomy (L-LC) in term of short and long-term outcome. Most of these articles revealed similar rate of surgical outcome except longer operating hours in R-LC which could be managed by encourage training system and education in robotic system as demonstrated in Table 4. A recent retrospective study by Lim et al. [61], compared robotic to laparoscopic left colectomy, revealed no significant difference between R-LC and L-LC in estimated blood loss, pathological and oncological outcome with favorable shorter hospital stay but longer operating time compared to laparoscopic surgery, rated at 252.5 ± 94.9 min in RLH and 217.6 ± 70.7 min in LLH (P=0.016).

In 2014, retrospective study by Casillas et al. [73], compared postoperative outcome between robotic and laparoscopic technique in colorectal procedures, included 68 patients underwent robotic and 81 patients laparoscopic left colectomies, found R-LC associated with longer operative time (188 min vs. 109 min, P<0.01), but significant shorter length of hospital stay (3.6 days vs. 6.5 days, P=0.01), lower conversion rate, less complication rate and bleeding rate than L-LC. Moreover Spingoli et al. [43] a prospective study, stated initial experience in 50 robotic cases in colorectal cancer, reported that robotic surgery is convenient, safe and feasible technology in the field of colorectal procedures without badly influenced on the oncological outcome with known time obstacle in robotic arm, which would be shorten by enhancing level of experiences and skills in robotic installations and procedures. Robotic colectomy is safe and promising technology in colorectal field with promising future.

Urogenital Function after Robotic TME for Rectal cancer

Identify pelvic autonomic plexus and neurovascular bundles during deep pelvic dissection are critical in order to preserve sexual and voiding function after TME in rectal cancer especially in young men [30,38]. Although up front chemo-radiation therapy (CRT) or adjuvant chemotherapy (AC) may deteriorate postoperative function, still intraoperative nerve crushed is the primary reason for sexual and urinary dysfunction [30,31]. Up scaling technical part and understanding the anatomy are a must in order to gain complete TME envelop with preserve pelvic plexus. However, TME principles are very challenging in a narrow or deep pelvis, therefore innovation of robotic system installed to assist surgeons with 3-dimensional surgical view, surgeon-operating camera system, filtering of tremor, and ergonomic instrumentation that facilitate fine dissection and stable traction to watch out these critical structures as well as to maintain integrity of TME envelop.

Sexual dysfunction

Overall sexual dysfunction after TME for rectal cancer rated at 11%-55% [74-76]. The main causes of genitourinary dysfunction are superior hypogastric plexus or sacral splanchnic nerves damages during surgery, resulted in urinary incontinence, retrograde ejaculation in men, and decreased orgasmic intensity in women [38,77,78]. In order to prevent sexual and urinary complications avoid common and potential sites of pelvic nerve damage, first, superior hypogastric plexuses that located close to IMA root, ejaculation dysfunction on male patients and impaired lubrication in females if injury occurred [2], second is pelvic splanchnic nerves or the pelvic plexuses located at posterolateral region of mesorectum, if injured will end with erectile dysfunction in men. Our experience in robotic rectal in term of earlier erectile recovery, sexual desire and urinary function compared to the laparoscopic group, nevertheless there was no significant difference in long-term follow-up.

Erectile dysfunction

Patriti et al. [22] reported erectile dysfunction rate of 5.5% and 16.6% in the robotic and laparoscopic group respectively with no statistical difference (p>0.05) along with worse dysfunction found in bulky tumors. In the Park et al. [50], patients asked to fill up a questionnaire before surgery, 3 and 6 months postoperatively, stated worse erectile dysfunction in laparoscopic group than robotic one, whereas similar urinary function. D'Annibale et al. [79] is prospective trial, reported 1-year follow-up assessment of erectile dysfunction, found marked erectile dysfunction in laparoscopic (13 out of 23; 56.5%) compared to robotic group (1 out of 17; 5.6%) (p=0.045), however loss of follow up in (LCS=23.3% vs. RCS=40.0%) should be considered carefully.

Interestingly Kim et al. [50] compared erectile dysfunction of robotic with laparoscopic TME [80], revealed faster recovery of sexual function in robotic than laparoscopic TME [6 months vs. 12 months] (p=0.036). A recent meta-analysis [81] compared LCS and RCS in sexual active patients postoperatively, showed better erectile function in RCS at 3 and 6 months follow up with p=0.002 vs. p=0.001 respectively. These characteristics of RCS can facilitate certain steps in rectal cancer such as: autonomic nerve preservation, ureter and gonadal vessel identification, dissection in the narrow pelvis, and dynamic suturing [82]. Quah et al. [76] suggested that autonomic nerve preservation is challenging in laparoscopic surgery, due to inadequate traction, whereas, a magnified view of R-TME could permit accurate observation of Denonvilliers fascia without injury of the neurovascular bundle.

Urinary retention

In general, 0%-27% is urinary dysfunction reported after TME for rectal cancer [75]. Throughout web sites, most of comparative studies have not showed significant differences yet in urinary or voiding dysfunction [10,50,59,83,84]. However kim et al. [60], found recovery of the urinary dysfunction after robotic TME faster (3 months) than laparoscopic TME (6 months), which could explain the rule and function of robotic system in proper visualization of hypogastric and pelvic plexus during critical points.

Fecal incontinent

Patriti et al. [22] reported 2.7% vs. 6.8% of fecal incontinence rate in laparoscopic and robotic groups respectively, without significant differences. We believe that enhance surgical view with 3-dimensional magnification (surgeon control) and ergonomic robotic instruments can facilitate preservation of the pelvic autonomic nerve which help to achieve favorable sexual, fecal and voiding functioning after rectal cancer surgery.

Limitation of Robotic Technique in Colorectal Surgery

Robotic setting

Docking and patient positioning, collisions are well known reason for unnecessary longer operation time and disrupting workflow [10]. Also, repeated docking and undocking of the robot is often needed when using the robot to perform surgical procedure in different compartments in the abdominal cavity, result in prolonged operating time and delayed conversion in case of massive bleeding [85].

Cost effectiveness of robotic surgery

Installation of robotic machine is expensive compared to laparoscopic surgery. In South Korea, national insurance covers most of the patient hospitality and surgery except robotic surgery because of lack of supportive evidence in robotic utilization. Therefore, penetration of robotic system in South Korea would be steady unless has reimbursed by national insurance. Park et al. [50] reported that overall hospital costs were higher in the RCS group (US $12235 vs. $10319.7) compared to LCS. Halabi et al. [86] illustrated significant higher total hospital fees in RCS, reached 12,965$US (P<0.001). kim et al. [87] studied cost effectiveness in R-TME compared to L-TME in 468 patients, reported higher cost and longer hospital stay in R-TME than L-TME, rated at ($9756.10 vs. $1724.80). Furthermore, the cost of robotic rectal surgery recorded as three times more than laparoscopic surgery [59,62]. Indeed, Robotic surgery is unable clarify the cost-effectiveness at this time, which has impact of robotic system penetration [88].

Despite early admission and lack of robotic justification and cost effectiveness, robot tracks the same channel where laparoscopic surgery was on. At the time of LCS admission in colorectal field, was costly without supportive resources, however, currently overall hospital cost of laparoscopic surgery has shown comparable to that of OCS due to reduction in the cost of post-operative care, hospital stay and faster return to activity. Therefore, the initial trial of robotic surgery would cost higher than LCS as it is new advent in the colorectal field without sufficient support. However, faster training curve, faster bowel recovery, lesser conversion rate and better function outcome would probably help to reduce the overall cost in the future. So, the cost is still an on-going obstacle in robotic surgery, cross this obstacle in the robotic road will enhance robotic sound in the field of colorectal surgery.

Lack of both tactile sensation and tensile feedback

This obstacle might result unexpected complication that can occur easily by excessive traction or accidental use of different robotic paddle which could cauterize ureter or vessels unintentionally [10]. Therefore, surgeon has to improve visual skills and accuracy to estimate the adequate amount of tension needed in several procedure steps. Likewise, caution should be taken during robotic suturing as suture could cut down with excessive tension [88]. Therefore, great care must be taken to avoid traumatic injuries when handling tissue.

Surgeon's experience and learning curve

Laparoscopic approach in colorectal surgery is challenging with relatively long learning curve [89]. Maggiori et al. [90] suggested to start laparoscopic training on stepwise manner, such as to start with benign tumor, then female T1, T2 rectal cancer till you gain adequate skills in L-TME afterwards. Moreover, 30 to 100 cases suggested overcoming difficult laparoscopic TME patients for instance; male, obese, narrow pelvic or radiated field. On the other hand, three-dimension view, dynamic movement, fines instruments and ergonomic shorten the journey in the learning curve of robotic surgery. The learning curve could be divided into three level as illustrated by Bokhari et al. [91] in a large retrospective study [CUSUM], includes 15 cases initially then additional 10 cases and putting hand on more complex condition afterword. Hence then, surgeon would achieve higher level of maturity and confidence in 15 to 25 operation [91].

Interestingly, surgeon adaptation for robotic surgery is very fast even with lack of laparoscopic skills; showed operative time may reduce in the first 20 cases [92]. Park et al. [93] found the learning curve after 17 cases. D'Annibale et al. [79], found mean operative time decreased from 312.5 min in the first 25 procedures to 238.2 min in the last 10 procedures (P=0.002). These results suggest robotic rectal surgery has a shorter learning curve than laparoscopic once, however park et al. [94] found similar learning curve for both laparoscopic and robotic surgery.

Future Aspect of Robotic Surgery

New release of robotic Da Vinci Xi stapler

These staplers designed to provide surgeons with natural dexterity, flexibility with 360 rotation and articulation. Da Vinci Xi stapler approved from the FDA in October 2012 for the Si version, and in 2014 for the Xi version. Currently, robotic stapler Si version approve in South Korea during the 1st quarter. Endo Wrist Stapler designed to ensure the function at its optimum, in term of resection, transection and anastomoses that provided with 3 staplers' lines. These staplers have several important functions in our practice, stapler estimate tissue thickness in which could help to select the proper stapler size and depth. Stapler has ability to study bowel viability and vascularity. Robotic stapler has a safety mark where you place tissue in between these marks.

Release of robotic stapler in the medical market is an evidence of smartness of robotic system and controlled completely by surgeon. Although, DaVinci Xi staplers are smart and effective, they brought to market in 45 mm size only which probably several staplers might use in a single operation which might increase the cost even further. DaVinci Xi stapler advent in the market should be carefully controlled and weight the risk and benefit of using such device in the future.

Indo-cyanine green [icg] dye

Intraoperative near infrared fluorescence (INIF) imaging uses laser technology to show an intravenously delivered agent. ICG is rapidly bound to plasma proteins, which allows ICG to remain longer in the blood vessels to facilitate its appearance clearly in vascular structures. Administration of INIF imaging system (Firefly) installed on the previous platform of Da Vinci Si has shown great success in our practice in several parameters. Firefly techniques assist to visualize and identify hidden vessels (arc of Riolan), evaluate vascularity status of bowel segments, hidden lymph nodes and determine tumor location. Robot is able to change normal visual system to the fluorescent mode that could identify ICG dye in the patient tissue within 50 seconds. ICG has a half-life of 2-5 minutes and is excreted mainly though the biliary system, making it impossible to visualize the ureters. The maximum dosage of ICG is 2 mg/kg. Utility of INIF imaging in performing robotic-assisted colorectal procedures is safe and effective to delineate vascular structure in simple pattern and mode switch [95].

Ongoing major clinical trails

Due to the limited evidence from RCT to support the use of robotic-assisted surgery for rectal cancer, the RO-botic versus LAparoscopic Resection for Rectal cancer (ROLARR) trial has been designed to address this issue [96]. Trial to Assess Robot-assisted Surgery and Laparoscopy-assisted Surgery in Patients with Mid or Low Rectal Cancer (COLRAR) is another ongoing trial [97,98]. This is an international, multicentric, prospective, randomized, controlled, unblinded, parallel-group trial of robotic-assisted versus laparoscopic surgery for the curative treatment of rectal cancer. The study will perform a detailed analysis of robotic-assisted rectal cancer surgery against conventional laparoscopic rectal cancer resection by means of a randomized, controlled trial.

Conclusion

Robotic colorectal surgery has just begun its primitive stage with great ability to approve its safety and feasibility in colorectal surgery. Robotic system is clearly an exciting technology with ability to overcome laparoscopic limitation in the field of colorectal surgery and may ensure improvements in postoperative outcome, enhancing the number of harvested lymph nodes, shorter hospital stay and faster urinary and sexual function. Nevertheless there is an increase of the procedure cost and longer operative time compared to laparoscopic surgery but there is a future prospective vision to approve cost effectiveness with upscale training level, upgrade skills and knowledge curve and popularity of robotic installations among medical stuffs. Adaptation to robotic system setting would help to compensate longer procedure time and facilitate better outcome in the field of colorectal surgery. Randomized clinical trials are needed to assert the true impact of robotic surgery in oncological outcome in colorectal surgery.

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