

Review

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Is robotic rectal resection the preferred option for resectable cancer?

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How to cite this article: Chouhan H, Shin J, Kim SH. Is robotic rectal resection the preferred option for resectable cancer? *Mini-invasive Surg* 2018;2:18. <http://dx.doi.org/10.20517/2574-1225.2018.40>

Received: 11 Jun 2018 **First Decision:** 2 Jul 2018 **Revised:** 16 Jul 2018 **Accepted:** 17 Jul 2018 **Published:** 20 Jul 2018

Science Editor: Gordon N. Buchanan **Copy Editor:** Jun-Yao Li **Production Editor:** Cai-Hong Wang

Abstract

The ultimate goal of rectal cancer surgery is to achieve a negative circumferential, distal resection margin and intact mesorectal excision; however, controversy remains as to what is the best approach. Based on the current evidence, open surgery remains the “gold standard”, however recent improvements in minimally invasive surgery (MIS) techniques with the introduction of robotic surgery and transanal total mesorectal excision have questioned the historical approach of open rectal dissection. A robotic system (da Vinci) overcomes many of the limitations of laparoscopic surgery. A robotic system is more like an open surgery: it gives a 3-dimensional magnified view, endowrist movements, has a shorter learning curve when compared with laparoscopic surgery, with the added advantage of an MIS procedure. However, the higher cost associated with robotic surgery has limited uptake of this approach in rectal cancer surgery in many parts of world.

Keywords: Rectal cancer, open surgery, robotic surgery

INTRODUCTION

Complete mesorectal excision in the total mesorectal excision (TME) plane, as popularised by Prof. Heald, is the ultimate goal of rectal cancer surgery, as this technique has been shown to reduce local recurrence rates. The controversy, though, lies in defining the best approach to achieve good quality TME. Laparoscopic colorectal resection has been shown to improve postoperative pain, reduce blood loss, reduce the ileus rate, as well as lead to earlier recovery and hospital discharge^[1]. However, data on oncological outcomes after



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laparoscopic rectal resection has shown no increase in overall or disease-free survival^[2-4], and studies have suggested caution in the use of laparoscopic surgery in rectal cancer surgery as it is associated with higher circumferential resection margin (CRM) positive rates, when compared with open surgery^[5]. Some inherent difficulties with laparoscopic surgery, such as working with rigid straight instruments in a narrow pelvis, 2-dimensional unmagnified views, and poor ergonomics, may have partly affected the oncological outcomes and increased the rates of positive CRM seen with laparoscopic surgery^[5].

A robotic platform overcomes some of the limitations of laparoscopic surgery, delivering magnified 3-dimensional views, articulating instruments, offering a stable platform, an extra arm for retraction, and the ability for the surgeon to sit and operate. A meta-analysis comparing laparoscopic surgery with robotic surgery in rectal cancer surgery has shown robotic surgery to be safe, and shown better mesolectal dissection with robotic surgery^[6,7]. Transanal TME (taTME) is a relatively new approach in rectal cancer resection and the oncological outcome of this approach is yet to be established in rectal cancer surgery. The aim of this review is to investigate the evidence and show that a robotic platform is the best minimally invasive surgery (MIS) approach for rectal cancer surgery.

WHY ROBOTIC SURGERY FOR RECTAL CANCER

Technical advantages of robotic surgery

A robotic platform, in comparison with laparoscopic surgery, is more ergonomic, reduces tremors, provides magnified 3-dimensional views, provides an extra working arm and gives the surgeon control of stable camera movements^[8]. All these advantages surely help surgeons perform a very precise dissection of the TME plane, preserving the autonomic nerves^[9]. However, due to the loss of haptic feedback with a robotic system, it is relatively easy to cause tissue damage during dissection and traction if not careful. A console surgeon can overcome the tactile feedback limitations of a robotic system by using visual cues, coupled with experience^[10].

Questionable safety of laparoscopic rectal dissection

Laparoscopic surgery has been shown to have improved short-term outcomes including less postoperative pain, reduced ileus rate, early discharge and return to work, however the safety of laparoscopic surgery in rectal cancer surgery is questioned. In a classic trial, laparoscopic surgery was associated with increased CRM positivity rates compared with open surgery (12.4% vs. 6.3%). Laparoscopic rectal cancer surgery in particular is associated with a higher conversion rate when compared with colonic laparoscopic resection, and those that are converted to open surgery have a higher mortality rate^[5,11]. This is a possible reflection of the technical challenges that confront a surgeon during rectal dissection. Recent multicentre randomized controlled trials (RCTs) have shown that the laparoscopic approach may have a higher potential for inferior quality TME^[12], however the long-term data on oncological outcomes are still awaited from these trials.

Potentially better oncological outcomes with robotic rectal surgery

A multicentre study reported excellent short term oncological outcomes with robotic rectal surgery (97% 3-year overall survival)^[13]. Non-randomised data out of Korea have shown similar results^[14]. The three-year overall survival is 93.1%, with disease-free survival of 79.2%, a low CRM positivity rate of 5.7% and a local recurrence rate of 3.6%: results which are equivalent to laparoscopic surgery from the same group^[15]. Although long term data on oncological outcomes with robotic rectal surgery are still lacking, better oncological outcomes and the low CRM positivity rates seen with robotic rectal surgery are a possible reflection of better visualisation, and the better ergonomic, stable platform that comes with robotic technology^[16,17].

Kim *et al.*^[18] recently reported a trend towards improved overall survival and cancer-specific survival rates with a robotic resection for mid to low rectal cancer (meaning the tumour height from the anal verge was 6.8 cm), compared with a laparoscopic resection in a retrospective, propensity score matched analysis (224 patients

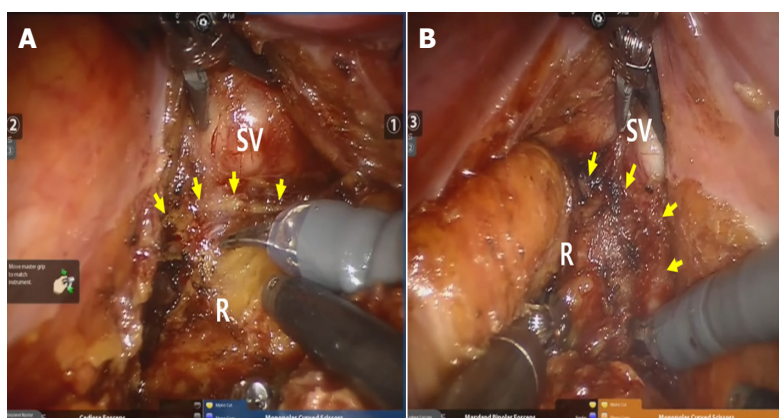


Figure 1. (A) The left neurovascular bundle (arrows) attached to the left seminal vesicle (SV) is dissected from the rectum (R); (B) the right neurovascular bundle (arrows) attached to the right SV is dissected from the R

each). In multivariate analyses, the robotic approach was a significant positive prognostic factor for overall survival and cancer-specific survival ($P = 0.0040$, $HR = 0.333$; $P = 0.0161$, $HR = 0.367$).

Lower conversion rates with robotic rectal surgery

As shown in a classic trial, higher conversion rates are associated with poor oncological outcomes and higher mortality. A meta-analysis comparing robotic surgery with laparoscopic surgery found robotic surgery to be associated with a lower conversion rate than open surgery^[19], a finding seen in two other studies^[20,21]. This potentially may allow the surgeon to complete many challenging rectal cancer cases using MIS with similar oncological outcomes. Data from the robotic vs. laparoscopic resection for rectal cancer (ROLARR) trial have shown that robotic surgery reduced the conversion rate in obese males with low rectal cancer, a challenging group for laparoscopic surgery^[22].

Shorter learning curve with robotic surgery

The learning curve for laparoscopic colorectal surgery ranges between 30-70 cases^[23]. A robotic platform which emulated open surgery with the advantage of a 3-dimensional magnified view, using articulating instruments (as compared with the straight instrument in laparoscopy) and better ergonomics has been shown to have a shorter learning curve, at some 20 cases^[24,25]. However, the loss of haptic feedback with robotic surgery may confound the robotic learning curve. An initial learning period of 30-40 cases and experience in visual cues lead to the second phase, where surgeons start taking on more complex cases.

Better chance for nerve preservation

Studies comparing sexual dysfunction between laparoscopic surgery and open surgery have shown that sexual function is significantly impaired after laparoscopic surgery^[26-28]. However, robotic surgery has shown improved post-operative sexual dysfunction and earlier functional recovery, compared with laparoscopic surgery^[29]. Improved sexual and urinary functions after robotic surgery are reflections of better nerve visualisations using a 3-dimensional magnified robotic platform [Figure 1].

Ability to assess vascularity of anastomosis

It is well known that distal perfusion is one of the main technical factors that affect the leak rate^[30]. Measures such as bleeding from marginal vessels, mesenteric vessel pulsation, a lack of distal end discoloration and negative leak tests are all unreliable and do not help predict postoperative leaks^[31]. Indocyanine green (ICG) which is absorbed near infrared light^[32] and detected by a robotic NIR camera system helps assess the distal bowel vascular supply and decrease anastomotic leak^[33]. In one study, the use of ICG has shown a 60% reduction in the leak rate^[34]. It also visualizes unusual vascular anatomy such as the Arc of Riolan^[35]. Use of

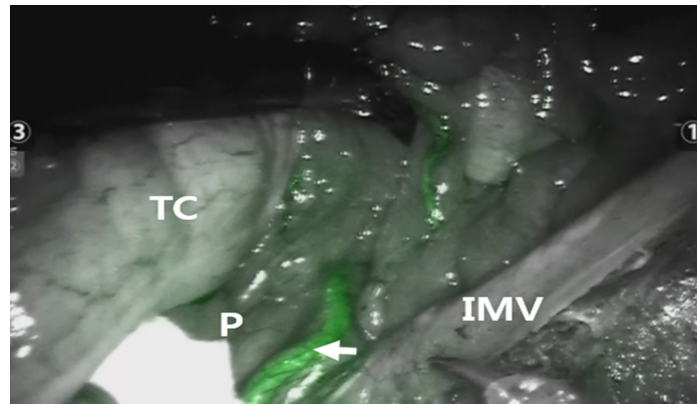


Figure 2. The Arc of Riolan (arrow) is highlighted by indocyanine green fluorescence during a high ligation of the inferior mesenteric vein (IMV) close to the pancreas (P). The transverse colon (TC) is cephalad retracted



Figure 3. The rectum is transected with guidance of indocyanine green fluorescence to confirm good perfusion on the distal rectal stump

ICG is also gaining popularity in identifying bilateral ureters and positive lateral pelvic lymph nodes during robotic rectal surgery [Figures 2 and 3].

The Arc of Riolan can be highlighted by indocyanine green fluorescence during a high ligation of the inferior mesenteric vein close to the pancreas. The transverse colon is cephalad retracted. When the Arc of Riolan exists, it should be preserved for better perfusion to the proximal segment of the anastomosis after rectal resection^[35] [Figures 2 and 3].

Ability to perform an advanced MIS procedure robotically

The optimal surgical approach for a positive lateral pelvic node has yet to be established in rectal surgery. Lateral node dissection is associated with increased blood loss and risk of damage to pelvic nerves, however the safety and feasibility of the robotic approach in pelvic lateral node dissection has been demonstrated^[36,37]. The ability to perform precise dissection with the stable robotic platform and the use of ICG to identify positive lateral nodes may potentially reduce the morbidity associated with this procedure.

Studies have shown that precise dissection of the lower rectum, in particular intersphincteric dissection, is associated with better long term functional and oncological outcomes^[38,39]. The robotic platform allows for a very precise dissection of the lower third of the rectum in the very confined space of the deep pelvis. Precise robotic intersphincteric dissection also potentially reduces the duration of the perineal procedure^[40,41].

Transanal TME vs. robotic TME

Despite advances in surgical management of rectal cancer, and advances in different minimally invasive approaches, achieving negative CRM remains a challenge, particularly in rectal tumours in the lower 1/3^[42]. To overcome this, and to avoid higher costs associated with robotic procedures, taTME has emerged as a new technique for performing rectal dissection^[43,44]. Proponents of taTME believe that this is the best approach for rectal dissection, as this technique offers great access to distal 1/3 rectal dissection, a good view of the pelvic anatomy, the ability to define the distal resection margin and potential for double purse-string anastomosis. A multicentre study comparing robotic TME to taTME has found that high quality TME can be achieved by both robotic and transanal approaches in skilled hands^[45]. However, long term data on oncological and functional outcomes of taTME are yet to be established.

CONCLUSION

Robotic rectal cancer surgery is safe and feasible and overcomes some of the shortcomings of laparoscopic surgery. This may be the reason why robotic surgery has better oncological and functional rates, along with lower conversion rates when compared with laparoscopic surgery. However, robotic surgery is yet to be compared with open surgery, “the gold standard of rectal cancer resection”. The higher costs associated with robotic surgery have been the major drawback in uptake of robotic surgery worldwide^[46]. However, new robotic platforms coming out in the future may reduce the cost of robotic surgery. Surgery technology continues to advance in order to overcome the limitation of current surgical practice. Innovation is rapid, but adoption of new technology occurs over time. Further prospective clinical trials will verify the true role of the robot in rectal surgery.

DECLARATIONS

Authors’ contributions

All authors made substantial contributions to: conception, design, acquisition and drafting the article and revising it critically for important intellectual content; and gave final approval of the version to be published.

Availability of data and materials

Not applicable.

Financial support and sponsorship

None.

Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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