

## Opinion Paper

James W.T. Toh, Kevin Phan and Seon-Hahn Kim\*

# Robotic colorectal surgery: more than a fantastic toy?

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**Abstract:** There has been a rapid rise in the number of robotic colorectal procedures worldwide since the da Vinci Surgical System robotic technology was approved for surgical procedures in the year 2000. Several recent meta-analyses and systematic reviews have shown a significant difference in outcomes between robotic and laparoscopic rectal cancer surgery. However, these results from pooled data have not been supported by the initial results reported from the Robotic assisted versus laparoscopic assisted resection for rectal cancer trial. In this article, we examine the current evidence for robotic colorectal surgery, assess its features and functionality, evaluate its learning curve and provide our perspective on its future.

**Keywords:** anterior resection; colorectal; robotic rectal surgery.

There has been a rapid rise in the number of robotic colorectal procedures worldwide since the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) robotic technology was approved for surgical procedures in the year 2000. However, robust clinical evidence supporting the benefit of robotic technology in the context of colorectal surgery remains limited.

A meta-analysis comparing laparoscopic and robotic colorectal surgery by Trastulli et al. [1] reported no significant difference in operation time, length of hospital stay,

morbidity and mortality, nor improvements in the quality of resection specimens. The only reported benefit reported by Trastulli et al. [1] was a reduction in conversion rate with robotic surgery (2% vs. 7.5%,  $p=0.0007$ ).

In contrast, several recent meta-analyses and systematic reviews have shown a significant difference in outcomes between robotic and laparoscopic rectal cancer surgery (Table 1). Sun et al. [2], Wang et al. [3] and Xiong et al. [4] have all reported lower rates of positive circumferential resection margin involvement, erectile dysfunction and conversion rate with robotic rectal cancer surgery. The study by Sun et al. [2] also reported shorter hospital stays and lower overall complication rates.

These results from pooled data have not, however, been supported by the initial results reported from the ROLARR (robotic-assisted versus laparoscopic-assisted resection for rectal cancer) trial [5, 6]. This trial has not demonstrated any statistically significant differences between laparoscopic- and robotic-assisted surgery [5, 6], with its long-term results widely anticipated.

A number of studies have also reported long-term 5-year survival data for robotic colorectal procedures in comparison with laparoscopic and open approaches (Table 2). The literature has been predominantly limited to level 3 evidence thus far. Matched comparisons by Kim et al. [7] and Cho et al. [8] have not shown statistically significant differences in 5-year overall survival or disease-free survival between robotic and laparoscopic colorectal surgery, although Kim et al. [7] did demonstrate a trend to improved survival.

It appears that the theoretical technical advantages in robotic surgery, such as with instruments that can rotate and bend in all directions, three-dimensional high-definition vision and surgeon-controlled multi-arms have not translated to huge benefits over traditional laparoscopic surgery. Opponents of robotic surgery believe that it is just a *fantastic toy*. We believe not.

First, the lack of reported benefits of robotic surgery over laparoscopic surgery may be associated with the general reporting of technically straightforward cases alongside technically difficult rectal cases. This may skew the results towards no difference, resulting in a type II error for technically difficult rectal cases. It is also important to

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**Table 1:** Key level evidence comparing outcomes of robotic vs. laparoscopic surgery for rectal cancer.

First author	Year	Journal	Study design	Level of evidence	CRM involvement	TME quality	Conversion to open
Jayne	2017	<i>JAMA</i>	Randomized controlled trial (n=471; 237 robotic, 234 laparoscopic)	Level 2	Similar (OR=0.78, p=0.56)	–	Similar (OR=0.61, p=0.16)
Prete	2017	<i>Ann Surg</i>	Meta-analysis (n=681 from 5 studies)	Level 1a	Similar	–	Lower in robotic: 7.3% (RR=0.58, 95% CI 0.35–0.97, p=0.04)
Li	2017	<i>Medicine (Baltimore)</i>	Meta-analysis (n=3601 from 17 studies)	Level 1b	Similar (OR=0.80, p=0.256)	–	Lower in robotic: 7.3% (OR=0.35, p<0.001)
Sun	2016	<i>World J Surg Oncol</i>	Meta-analysis (n=592 from 8 studies)	Level 1b	Lower in robotic (OR=0.5, 95% CI 0.25–1.01, p=0.05)	–	Lower in robotic (OR=0.08, 95% CI 0.02–0.31, p=0.0002)
Wang	2016	<i>Surg Laparosc Endosc Percutan Tech</i>	Meta-analysis (n=1229 from 8 studies)	Level 1b	Lower in robotic (OR=0.44, 95% CI 0.20–0.96, p<0.05)	–	Lower in robotic (OR=0.23, 95% CI 0.10–0.52, p<0.01)
Speicher	2015	<i>Ann Surg</i>	US National Cancer Database (n=6403 in 2011–2012; 956 robotic)	Level 3b	Similar (5.5% vs. 4.7%)	–	Lower in robotic (9.5% vs. 16.4%, p<0.001)
Xiong	2015	<i>J Gastrointest Surg</i>	Meta-analysis (n=1229 from 8 studies)	Level 1b	Lower in robotic (2.7% vs. 5.8%; OR=0.44, 95% CI 0.20–0.96, p=0.04)	–	Lower in robotic (OR=0.23, 95% CI 0.10–0.52, p=0.0004)

CRM, circumferential resection margin; TME, total mesorectal excision; OR, odds ratio; CI, confidence interval; RR, relative risk; –, not reported.

understand the generalisability of pooled data – and to analyse data for specific patient subgroups, particularly for robotic surgery in order to justify its expense, as the major advantage of robotic technology is confined to a smaller cohort of patients with low rectal tumours, narrow pelvis and obesity [5]. The consensus statement regarding the use of robotics in general surgery has surmised that the advantage of robotic surgery is mainly within confined spaces [9].

Patient selection is the key. With the use of the procedure-targeted database of the American College of Surgeons National Surgical Quality Improvement Program, after matching patients based on gender, body mass index, surgical procedure, diagnosis and American Society of Anesthesiologists classification, Benlice et al. [10] reported shorter hospital stay, lower morbidity, superficial surgical site infection, transfusion requirement and ileus associated with robotic surgery over traditional laparoscopic surgery in matched patients.

In technically challenging cases, most surgeons who perform both robotic and laparoscopic surgery would anecdotally agree that robotic technology protects against conversion to open, with the superiority of robotic instruments over laparoscopic rigid instruments and significantly better vision of the surgical field associated with robotic technology. The better stereo-optic three-dimensional vision, self-controlling camera and instruments

with seven degrees of freedom and motion scaling, as well as ergonomic comfort for the surgeon improve the accuracy of surgical dissection. A recent study by Ahmed et al. [11] focusing on high-risk patients (body mass index  $\geq 30$ , male gender, preoperative chemoradiotherapy, tumour <8 cm from the anal verge, previous abdominal surgery) demonstrated that robotic surgery in high-risk patients resulted in higher rates of sphincter preservation; lower conversion rates, operating times and blood loss; and shorter length of stay.

However, it would be a mistake to reserve robotic technology only for complex cases, as there is a steep learning curve and longer operating time associated with learning to use robotic technology. The number of cases required for expertise in robotic surgery has been reported in several studies. There is a wide discrepancy within the literature. Herrell and Smith [12] indicated that at least 150 cases were required for proficiency. Meanwhile, the study by Ahlering et al. [13] suggested that only 9–12 cases were required to achieve proficiency. Ou et al. [14] reported that the incidence of positive surgical margins in robotic surgery decreased significantly after 250 cases. There needs to be sufficient caseload for training, credentialing and maintaining robotic skills. Some argue that the theoretical advantage of robotic surgery over laparoscopic surgery is skewed towards no difference due to the learning curve associated with robotic surgery, as most

**Table 2:** Key long-term 5-year survival data for robotic vs. laparoscopic surgery for rectal cancer.

First author	Year	Journal	Study design	Level of evidence	Local recurrence	5-Year OS	5-Year DFS	5-Year CSS
Sujatha-Bhaskar	2017	<i>Ann Surg</i>	US National Cancer Database (905 robotic vs. 2009 lap vs. 3399 open)	Level 3	–	78% (robotic) vs. 81% (lap) vs. 76% (open), p=0.0198	–	–
Kim	2017	<i>DCR</i>	Single centre (224 robotic vs. 224 lap)	Level 3	5.6% vs. 7.3% (p=0.502)	91% vs. 78% (p=NS)	73% vs. 68% (p=NS)	91% vs. 80% (p=NS)
Sammour	2017	<i>Ann Surg</i>	Single centre (276 robotic)	Level 3	2.40%	87%	82%	–
Cho	2015	<i>Medicine (Baltimore)</i>	Single centre (278 robotic vs. 278 lap)	Level 3	5.9% vs. 3.9% (p=0.313)	92% vs. 93% (p=NS)	82% vs. 80% (p=NS)	–
Ghezzi	2014	<i>EJSO</i>	Two centres (65 robotic vs. 109 open)	Level 3	3.4% vs. 16.1% (p=0.024)	85% vs. 76% (p=NS)	73% vs. 70% (p=NS)	–

OS, overall survival; DFS, disease-free survival; CSS, cancer-specific survival; lap, laparoscopic; NS, not significant.

colorectal surgeons in this era are experienced laparoscopic surgeons and novice robotic surgeons. With time and experience, the operation time and other parameters associated with robotic surgery should improve, and the advantage of robotic surgery may be realised.

At our institution, we reserve robotic technology mainly for middle and low rectal cancers, and we do not use robotic technology for purely colonic nor for upper rectal cancer cases. A randomised clinical trial by Park et al. [15] showed that robotic-assisted laparoscopic right hemicolectomy provided no significant benefit over conventional laparoscopic right hemicolectomy to justify its cost. We do not believe that there is any major theoretical nor reported clinical benefit for robotics in purely colonic cases, and use robotics in selected upper rectal cases only.

Apart from improvements in short-term outcomes and conversion rates, using our own data and experience, we reported on the long-term outcomes of robotic and laparoscopic total mesorectal excision for mid and low rectal cancers (robotic, n=272; laparoscopic, n=460), showing that the robotic procedure is a positive prognostic factor in rectal cancer surgery [7]. Our study was the first in the literature to do so. After propensity scoring, we showed that our technique of single-docking totally robotic surgery was associated with a trend to improved survival. Also, in multivariate analysis, robotic surgery was a significant prognostic factor for overall survival and cancer-specific survival.

Multiple platforms are already capable of utilizing robotic surgery. These include single-incision/port surgery, robotic natural orifice transluminal endoscopic surgery, robotic transanal surgery and endo-robotics. Alongside the well-known da Vinci platform, new commercial biomedical companies including Titan Medical Inc., Endomina, Medrobotics, Flex-robotics, Memic Innovative

Surgery, TransEnterix, Robot Surgeon and Auris Robotics are emerging, and we look forward to next-generation robotic systems, which represent an exciting frontier.

A *toy* is defined as a thing of little or no value or importance, something that does not have serious practical use, but rather is a trifle that diverts attention, mainly for amusement but with no real practical importance. We believe that robotic colorectal surgery is far from that. Rather, if we were to use a sporting metaphor, the robot is more like an impact player reserved for important rounds. The impact player makes the biggest difference when it counts, rather than in easy victories. However, it would be a strategic mistake to bring out the impact player only in the *grand finale*, as the team needs time and experience to work with the impact player to achieve and ensure the best outcomes.

#### Author Statement

Research funding: Authors state no funding involved. Conflict of interest: Authors state no conflict of interest. Informed consent: Informed consent is not applicable. Ethical approval: The conducted research is not related to either human or animals use.

#### Author Contributions

James Toh: writing – original draft; writing – review and editing; Seon-Hahn Kim: writing – original draft; writing – review and editing; Kevin Phan: writing – original draft.

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**Supplemental Material:** The article (<https://doi.org/10.1515/iss-2017-0046>) offers reviewer assessments as supplementary material.

## Reviewer Assessment

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## Reviewers' Comments to Original Submission

### Reviewer 1: anonymous

Dec 11, 2017

<b>Reviewer Recommendation Term:</b>	Reject
<b>Overall Reviewer Manuscript Rating:</b>	N/A
<b>Custom Review Questions</b>	<b>Response</b>
Is the subject area appropriate for you?	5 - High/Yes
Does the title clearly reflect the paper's content?	3
Does the abstract clearly reflect the paper's content?	1 - Low/No
Do the keywords clearly reflect the paper's content?	2
Does the introduction present the problem clearly?	1 - Low/No
Are the results/conclusions justified?	1 - Low/No
How comprehensive and up-to-date is the subject matter presented?	2
How adequate is the data presentation?	1 - Low/No
Are units and terminology used correctly?	3
Is the number of cases adequate?	1 - Low/No
Are the experimental methods/clinical studies adequate?	1 - Low/No
Is the length appropriate in relation to the content?	1 - Low/No
Does the reader get new insights from the article?	1 - Low/No
Please rate the practical significance.	2
Please rate the accuracy of methods.	1 - Low/No
Please rate the statistical evaluation and quality control.	1 - Low/No
Please rate the appropriateness of the figures and tables.	1 - Low/No
Please rate the appropriateness of the references.	2
Please evaluate the writing style and use of language.	3
Please judge the overall scientific quality of the manuscript.	1 - Low/No
Are you willing to review the revision of this manuscript?	No

### Comments to Authors:

-

## Additional Comments from Reviewer 1

This article certainly breathes the best spirit of surgery: To move forward what is considered to be reasonable and to fight intensively what is thought to be progress.

In this paper, the authors argue with a vengeance in favor of colorectal robotic surgery.

Currently, we are within an intensive, and sometimes even passionate, debate upon the role of “robotic surgery”. In a sober, critical analysis of the flood of reports, meta-analyses and even prospective randomized trials no other conclusion is left than robotic surgery being feasible but not superior.

The authors’ opinion is different. After a general analysis of the literature which fails to prove the necessity to use telemanipulation systems, he is nonetheless convinced that the use of a telemanipulation system is justified in “difficult” colorectal cases. A logical consequence of this statement would be “to reserve robotic technology only for complex cases” as he points out explicitly. This, however, is denied since “normal” cases are required to achieve and maintain a high training level with the device. This might be an acceptable point of view but it implicitly means that telemanipulation systems are only adequate in specialized centers with a high caseload of complex interventions. This important conclusion should be stated clearly.

## Reviewer 2: Roland Croner

Dec 27, 2017

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<b>Reviewer Recommendation Term:</b>	Revise with Mino Modification
<b>Overall Reviewer Manuscript Rating:</b>	N/A
<b>Custom Review Questions</b>	<b>Response</b>
Is the subject area appropriate for you?	3
Does the title clearly reflect the paper’s content?	4
Does the abstract clearly reflect the paper’s content?	4
Do the keywords clearly reflect the paper’s content?	5 - High/Yes
Does the introduction present the problem clearly?	4
Are the results/conclusions justified?	5 - High/Yes
How comprehensive and up-to-date is the subject matter presented?	5 - High/Yes
How adequate is the data presentation?	5 - High/Yes
Are units and terminology used correctly?	5 - High/Yes
Is the number of cases adequate?	4
Are the experimental methods/clinical studies adequate?	4
Is the length appropriate in relation to the content?	3
Does the reader get new insights from the article?	5 - High/Yes
Please rate the practical significance.	5 - High/Yes
Please rate the accuracy of methods.	4
Please rate the statistical evaluation and quality control.	4
Please rate the appropriateness of the figures and tables.	5 - High/Yes
Please rate the appropriateness of the references.	5 - High/Yes
Please evaluate the writing style and use of language.	4
Please judge the overall scientific quality of the manuscript.	5 - High/Yes
Are you willing to review the revision of this manuscript?	Yes

### Comments to Authors:

Very well written paper on robotic surgery and the development of robotic-assisted rectal surgery over the last years. The endpoints of the manuscript concerning the use of robotic surgery are well demonstrated.

Minor concerns:

1. The authors could mention the longer operating times (in comparison to laparoscopic surgery) at the beginning of the learning curve.
  2. Do the authors not see any benefit (in comparison to laparoscopic surgery) by the use of robotic surgery in cases of right/sided carcinomas in terms of CME, technical feasibility and quality of specimen?
-



**Reviewer 3: anonymous**

Jan 30, 2018

<b>Reviewer Recommendation Term:</b>	Accept
<b>Overall Reviewer Manuscript Rating:</b>	40
<b>Custom Review Questions</b>	<b>Response</b>
Is the subject area appropriate for you?	5 - High/Yes
Does the title clearly reflect the paper's content?	4
Does the abstract clearly reflect the paper's content?	3
Do the keywords clearly reflect the paper's content?	3
Does the introduction present the problem clearly?	4
Are the results/conclusions justified?	2
How comprehensive and up-to-date is the subject matter presented?	4
How adequate is the data presentation?	N/A
Are units and terminology used correctly?	N/A
Is the number of cases adequate?	N/A
Are the experimental methods/clinical studies adequate?	N/A
Is the length appropriate in relation to the content?	4
Does the reader get new insights from the article?	3
Please rate the practical significance.	3
Please rate the accuracy of methods.	N/A
Please rate the statistical evaluation and quality control.	N/A
Please rate the appropriateness of the figures and tables.	3
Please rate the appropriateness of the references.	3
Please evaluate the writing style and use of language.	3
Please judge the overall scientific quality of the manuscript.	3
Are you willing to review the revision of this manuscript?	No: Since the article is classified as "Opinion Paper" and therefore clearly reflects the authors' opinion I feel that a revision is not necessary.

**Comments to Authors:**

As the authors correctly state: there is huge evidence of increasing importance of robotic surgery not only in General, but also in urologic and gynecologic. Up till now, however, there is no existing evidence that robotic surgery really is better than laparoscopic surgery. For these reasons, it is absolutely the authors' opinion that robotic surgery is more than a fantastic toy. The Readers of this article must be aware of this fact.

**Authors' Response to Reviewer Comments**

Feb 08, 2018

Thank you for your comments. We have addressed all of the reviewers' comments and made the minor corrections as requested.

## Reviewers' comments:

**Reviewer #2:** Very well written paper on robotic surgery and the development of robotic-assisted rectal surgery over the last years. The end-points of the manuscript concerning the use of robotic surgery are well demonstrated.

## Minor concerns:

1. The authors could mention the longer operating times (in comparison to laparoscopic surgery) at the beginning of the learning curve.  
Done
2. Do the authors not see any benefit (in comparison to laparoscopic surgery) by the use of robotic surgery in cases of right/sided carcinomas in terms of CME, technical feasibility and quality of specimen?

We do not believe there is a major benefit for robotics in right sided colon cancer surgery.

Br J Surg (2012) Randomized clinical trial of robot-assisted versus standard laparoscopic right colectomy. Park JS1, Choi GS, Park SY, Kim HJ,

Ryuk JP concluded that ‘robotic-assisted laparoscopic right hemicolectomy was feasible but provided no benefit to justify the greater cost.’

**Reviewer #3:** As the authors correctly state: there is huge evidence of increasing importance of robotic surgery not only in General, but also in urologic and gynecologic. Up till now, however, there is no existing evidence that robotic surgery really is better than laparoscopic surgery. For these reasons, it is absolutely the authors’ opinion that robotic surgery is more than a fantastic toy. The Readers of this article must be aware of this fact.

This is incorrect - it is not just our opinion that robotic surgery has benefit (we have provided evidence from several meta-analyses of benefit). Secondly, in this opinion paper, we have not stated that there is ‘huge evidence of increasing importance’ in robotic surgery. Albeit there is evidence in the literature that robotic surgery provides benefit in rectal cancer surgery. These meta-analyses which we have mentioned in our article have shown reduced conversion to open in rectal cancer surgery and improved short term outcomes.

Ortiz-Oshiro E, Sanchez-Egido I, Moreno-Sierra J, Perez CF, Diaz JS, Fernandez-Represa JA. Robotic assistance may reduce conversion to open in rectal carcinoma laparoscopic surgery: systematic review and meta-analysis. The international journal of medical robotics + computer assisted surgery : MRCAS. 2012;8:360-370. Sun Y, Xu H, Li Z, et al. Robotic versus laparoscopic low anterior resection for rectal cancer: a meta-analysis. World Journal of Surgical Oncology. 2016;14:61.

## Reviewers’ Comments to Revision

### Reviewer 2: Roland Croner

Mar 06, 2018

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<b>Reviewer Recommendation Term:</b>	Accept
<b>Overall Reviewer Manuscript Rating:</b>	70
<b>Custom Review Questions</b>	<b>Response</b>
Is the subject area appropriate for you?	5 - High/Yes
Does the title clearly reflect the paper’s content?	5 - High/Yes
Does the abstract clearly reflect the paper’s content?	4
Do the keywords clearly reflect the paper’s content?	5 - High/Yes
Does the introduction present the problem clearly?	5 - High/Yes
Are the results/conclusions justified?	5 - High/Yes
How comprehensive and up-to-date is the subject matter presented?	4
How adequate is the data presentation?	3
Are units and terminology used correctly?	5 - High/Yes
Is the number of cases adequate?	4
Are the experimental methods/clinical studies adequate?	5 - High/Yes
Is the length appropriate in relation to the content?	4
Does the reader get new insights from the article?	5 - High/Yes
Please rate the practical significance.	5 - High/Yes
Please rate the accuracy of methods.	5 - High/Yes
Please rate the statistical evaluation and quality control.	3
Please rate the appropriateness of the figures and tables.	3
Please rate the appropriateness of the references.	5 - High/Yes
Please evaluate the writing style and use of language.	5 - High/Yes
Please judge the overall scientific quality of the manuscript.	5 - High/Yes
Are you willing to review the revision of this manuscript?	Yes

#### Comments to Authors:

The authors addressed the reviewer’s concerns adequately. All necessary changes have been carried out. The manuscript should be published in the present form.

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