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Successful patient orientated surgical outcomes in robotic versus laparoscopic right hemicolectomy for cancer – a systematic review

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Abstract

Introduction:

Minimally invasive surgical approaches for cancer of the right colon have been well described with significant patient and equivalent oncological benefits. Robotic surgery has advanced in its ability to provide multi-quadrant abdominal access, leading the surgical community to widen its application outside of the pelvis to other abdominal compartments. Globally it is being realised that a patient's surgical episode of care is becoming the epicentre of cancer treatment. In order to establish the role of robotic surgery in a patient's episode of care, "successful patient-orientated surgical" parameters in right hemicolectomy for malignancy were measured.

Objectives :

To examine the rates of successful patient orientated surgical outcomes in robotic right hemicolectomy (RRH) compared to laparoscopic right hemicolectomy (LRH) for cancer.

Methods:

A systematic search of Medline (Ovid: 1946-present), PubMed (NCBI), EMBase (Ovid: 1966-present), and Cochrane Library was conducted using PRISMA for parameters of successful patient orientated surgical outcomes in robotic and laparoscopic right hemicolectomy for malignancy alone. The parameters measured included post-operative ileus, anastomotic complication, surgical wound infection, length of stay, incisional hernia rate, conversion to open, margin status, lymph node harvest and overall morbidity and mortality.

Results:

There were 15 studies which included 831 RRH patients and 3241 LRH patients, with the median age range between all studies of 62 to 74 years. No study analysed the concept of successful patient orientated surgical outcomes. There was no significant difference in the incidence of post-operative ileus, with less time to first flatus in RRH (2.0 to 2.7 days, compared with 2.5 to 4.0 days, $p<0.05$). Anastomotic leak rate in one study reported a significant increase in LRH compared to RRH ($p<0.05$, 0% v 8.3%). Significantly decreased LOS following RRH was outlined in 6 studies. In one study a significantly higher rate of incisional hernias following LRH with extracorporeal anastomoses compared to RRH with intracorporeal anastomoses. Overall rates of conversion to open surgery were less with RRH (0% to 3.9% v 0 – 18%, $p<0.001$, 0.05). One study outlined significantly higher rates of incomplete resection with an open right hemicolectomy when compared with minimally invasive laparoscopic and robotic resections, with positive margin rates of 2.3%, 0.9% and 0% respectively ($p<0.001$). Two studies reported significantly higher lymph node harvest in RRH ($p<0.05$). Overall morbidity and 30-day mortality were comparable between both approaches.

Conclusion:

Thirty-day morbidity and mortality was comparable between both approaches, with patients undergoing RRH having significantly lower anastomotic complications, increased lymph node harvest, reduced length of stay, conversion to open and incisional hernia rates in a number of studies. There is limited data on surgical approach and impact on quality of life and what patients deem successful surgical outcomes. There is a further need for a randomised control trial examining successful patient orientated outcomes in right hemicolectomy for malignancy.

Originality statement:

Thirty-day morbidity and mortality was comparable in both approaches. Patients undergoing robotic surgery had significantly lower anastomotic complications, increased lymph node harvest, reduced

hospital stay, conversion to open and incisional hernia rates in a number of studies. There is limited data on surgical approach and impact on quality of life.

Introduction

Surgery remains the cornerstone for cure in colonic malignancy (1). Minimally invasive surgical approaches to the right colon for cancer have been well described with significant patient and equivalent oncological benefits (2, 6). To date, numerous studies have demonstrated clear advantages of laparoscopic over open surgical resection (7, 8). Robotic surgery has advanced in its ability to facilitate multi-quadrant abdominal access and dissection by providing three-dimensional imaging, stable optical platforms with improved arm articulation, leading the surgical community to widen its application beyond pelvic surgery to other abdominal oncological resections (9-11). Currently, right hemicolectomy for cancer is predominantly performed in high volume centres via a laparoscopic approach (12). With increases in availability, application and adaptability, debate now exists whether advanced surgical platforms such as robotics for oncological colonic resection would translate to disease, patient and economic benefits. Advocates of robotic interventions performing routine robotic colonic surgery report improved visualisation, precision of oncological dissection and the ability to routinely perform intracorporeal anastomosis (13). It is well documented that precision of oncological resections in colon cancer has a definite impact on cancer recurrence and survival (14). In light of this, working groups are now advocating the use of such platforms to perform routine colonic resection and complete mesocolic excisions (CME) where indicated to maximise efficiency of lymph node harvest and a corresponding improved local recurrence rate (15, 16).

Globally it is being realised that a patient's surgical episode of care is becoming the epicentre of cancer treatment. With health care reforms internationally, there has been proposals for the use of an episode of patient care as a basis of highlighting medical performance, financial reimbursement and most importantly a recording of patient experience (17-19). Episode-based approaches are constructed to improve delivery of healthcare and more importantly promote quality, safety and

efficiency in surgery (20). It is postulated that such novel technically advanced operative interventions such as robotics is related to an overall improved patient episode and hospital experience. Previous studies attempting to elucidate the potential benefits of robotic colonic surgery were associated with significant shortcomings due to inappropriate primary and secondary endpoints commonly reported in traditional open and laparoscopic approaches which did not encompass factors associated with a patient episode of care (21). This was further compounded by the fact that several studies were limited by their retrospective design and reduced patient numbers in the robotic intervention arm (22, 23). In order to establish the role of robotic surgery in a patient's episode of care in right hemicolectomy for malignancy it is important to define the key aspects of "successful patient orientated surgery". The concept of a successful surgical episode has been previously described, however with preliminary pilot patient interviews being performed by the current authors on patients undergoing oncological colorectal resection the concept of "successful patient orientated surgery" in RRH is a combination of symptom and clinical outcomes. Such reported parameters of importance by patients include absence of ileus with patients tolerating diet by day two, no anastomotic complication (leak or haemorrhage), absence of surgical site infection, discharge within 3 days without unplanned readmission, no incisional hernia at 12 months, no conversion to open surgery or significant post-operative complication (Clavien-Dindo grades III or higher) and clear oncological margins (24). To date, studies examining successful patient orientated outcomes in minimally invasive surgical approaches to the right colon for malignancy are scant. The primary objective of this study, therefore, was to examine the concept and determine the rates of successful patient orientated surgery in robotic right hemicolectomy (RRH) compared to laparoscopic right hemicolectomy (LRH) for cancer.

Methods

Search Strategy

A systematic review of published work was conducted as per the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement for the conduct of a review study. The study team developed a concept table and built a search strategy with a medical librarian to identify articles reporting outcomes on components of successful patient orientated surgical outcomes in robotic versus laparoscopic right hemicolectomy for cancer. Two concepts were developed: Robotic and Laparoscopic types of surgery. Exploded medical subject heading (MeSH) terms were combined with text word searching using the Boolean operator 'OR' for each concept. Each concept was combined with 'AND'. Variation in spelling were accounted for using '*' in the search to represent

wildcard characters. No search limits were applied and all languages were included. Five databases were searched; Medline (Ovid:1946-present), PubMed (NCBI), EMBase (Ovid:1966-present) and Cochrane Library. The final search date was 3rd March, 2019. Reference lists of included articles were also searched and further articles included if appropriate. The full search strategy used is summarised in Figure 1 and Appendix 1.

Inclusion & Exclusion Criteria

To minimise selection, reporting and publication bias, any case reports or small series from single centres (≤ 5 patients) were excluded. The criteria were also refined to studies reporting oncological, patient and 30-day morbidity for robotic versus laparoscopic right hemicolectomy for cancer in humans with a median age ≥ 18 years. Studies reporting surgical outcomes that included patients operated on for non-cancer pathologies were excluded. Furthermore, studies including other forms of colorectal resection (i.e ileocolic, limited right hemicolectomy, caecectomy, ileocaecectomy and extended right hemicolectomy etc.), surgical approach (open or hand port assisted) or hybrid procedures were excluded if reported primary surgical outcomes/endpoints which were set prior to the search strategy were not specified between the operative approaches. In case of overlapping of data reporting outcomes in studies from a single institution/database, the largest study from that dataset was included.

Study Selection

Using pre-defined data fields, two authors independently assessed the study titles and abstracts for inclusion. They discussed and resolved any differences in title selection between them, with a third assessor independently reconciling any differences in abstract selection. Full-text versions of potentially eligible studies were retrieved, which were further assessed by two independent study authors against the inclusion/exclusion criteria and a consensus was reached.

Data Extraction & Outcomes

One author extracted information from the studies using a standardised spreadsheet. Data extracted included study year, study design and purpose, patient demographics, cancer stage, conversion to open procedure, morbidity and mortality, type of surgical resection and length of follow-up.

Risk of Bias Assessment

Two study authors assessed risk of bias independently and a third author resolved any discrepancies, using the Newcastle Ottawa Scale for cohort studies and Cochrane Risk of Bias Tool for Randomised Controlled Trials (RCT). Data recorded included incomplete outcome data, clearly defined outcome

measures and other sources of bias. Studies were assigned a score based on selection, comparability and outcome using the published criteria.

Data Synthesis

The heterogeneous nature of the methodology and data collected from this systematic review did not allow meta-analysis to be conducted.

Results

Search Results

The final 15 studies selected for this systematic review (figure 1) included 14 retrospective studies and 1 prospective RCT. All studies were published within the last 9 years and the study periods ranged from 1998 to 2017. The total patient numbers in all included studies were 831 RRH patients and 3241 LRH patients, with the median age range between all studies of 62 to 74 years. All 15 robotic studies and 14 laparoscopic studies (excluding deAngelis et al) reported a median or mean operative time. RRH operative time was found to be significantly increased when compared to LRH in 13 studies ($p < 0.05$, 0.01, 0.001, 0.0001).

Primary Surgical Endpoints

POST-OPERATIVE ILEUS/RETURN OF BOWEL FUNCTION

The incidence of post-operative ileus was reported in 10 studies with rates between 0% to 12.4% and 0% to 13% for RRH and LRH, respectively (25-33). No study reported a significant difference between robotic and laparoscopic approaches (table 2). Haskins et al. reported a significant difference in rates of post-operative ileus between open and minimally invasive (robotic/laparoscopic) approaches to right hemicolectomy ($p < 0.001$) but no significant difference in outcomes between RRH and LRH were found (27). Trastulli et al. was the only study that compared intracorporeal and extracorporeal anastomoses in laparoscopic procedures, reporting post-operative ileus rates of 2.5% and 3.2%, respectively with no significant difference between anastomotic techniques (31). While three studies contained robotic cohorts undergoing both intracorporeal and extracorporeal anastomoses, no studies performed subset analysis comparing anastomotic techniques in robotic procedures (29, 32, 34). Median days to first flatus was also reported in 10 studies (25, 27-31, 33-36) and 4 of these reported significantly fewer days to first flatus following RRH, between 2.0 to 2.7 days, compared with 2.5 to 4.0 days following LRH (28, 31, 35, 36).

ANASTOMOTIC COMPLICATIONS

The rate of anastomotic leak was reported in 10 studies, with only 1 study reporting a significant difference between RRH and LRH (table 2). Morpugo et al. compared RRH with intracorporeal anastomosis and LRH with extracorporeal anastomosis, identifying a significantly higher rate of anastomotic leak ($p < 0.05$) following LRH of 8.3% compared with 0% following RRH (35). Otherwise no other included study reported a difference between groups with a range of 0% to 2.9% for RRH and 0% to 10% for LRH (25, 28-33, 35, 36). Megevan et al. was the only study that reported rates of anastomotic bleeding with 4% following RRH with intracorporeal anastomosis and 6% following LRH with either intracorporeal or extracorporeal anastomoses (28).

SURGICAL WOUND INFECTION

Surgical site infections were reported in 10 studies with similar rates ranging between 0% to 15% following RRH and 0% to 14.6% following LRH (26, 27, 28-33, 35, 36). No significant difference between rates of wound infections was found in any study. Trastulli et al. compared intracorporeal and extracorporeal anastomoses in laparoscopic procedures, reporting wound infection rates of 10% and 5.3%, respectively with no significant difference between anastomotic techniques (31). No studies performed subset analysis comparing wound infection rates between anastomotic techniques in robotic procedures (29, 32, 34).

LENGTH OF STAY

All included studies reported either median or mean hospital length of stay (LOS). Overall median LOS following RRH ranged between 4 to 8.5 days and following LRH ranged between 4.5 to 9 days (27, 31, 37). Significantly lower hospital LOS following RRH was outlined in 6 studies ($p < 0.001$, 0.05), however 2 of these studies, Haskins et al. and Scotton et al., reported LOS as a mean (26-28, 31, 35, 36).

INCISIONAL HERNIA

The incidence of incisional hernias following minimally invasive right hemicolectomy was only reported in 3 studies and ranged between 0% to 17% and 2.5% to 22% following RRH and LRH respectively (32, 35, 36). Widmar et al. primarily aimed to examine the incidence of incisional hernias with follow up periods of 12 months following RRH and 30 months following LRH. This study demonstrated considerably higher rates of incisional hernias than the other 2 included studies, but similar to Scotton et al. showed no significant difference in incidence between RRH and LRH (32). Morpugo et al. outlined a significantly higher rate of incisional hernias following LRH with extracorporeal anastomoses (8.3%) when compared with hybrid RRH with intracorporeal anastomoses (0%) with a follow up period of 13 to 35 months (35).

CONVERSION TO OPEN LAPAROTOMY

Overall rates of conversion to open surgery during RRH ranged from 0% to 3.9% and during LRH ranged from 0% to 18.1% (28, 30, 36). In the 10 studies that reported rates of conversion, 3 studies identified a significantly lower rate of conversion during RRH (28, 30, 36). Spinoglio et al.

retrospectively compared robotic and laparoscopic approaches to right hemicolectomy with uniform complete mesocolic excision and intracorporeal anastomosis between groups, finding a significantly lower rate of open conversion during RRH (0%) compared with LRH (6.9%, $p < 0.001$, 0.05) (30).

COMPLETENESS OF RESECTION

Completeness of resection and mean distal resection margin was reported in 5 studies, with 3 studies reporting complete (R0) resection achieved for all robotic and laparoscopic patients (29, 33, 38). No study reported significant differences between surgical approaches. Haskins et al. outlined significantly higher rates of incomplete resection with an open right hemicolectomy when compared with minimally invasive laparoscopic and robotic resections, with positive margin rates of 2.3%, 0.9% and 0% respectively ($p < 0.001$) (26). Mean lymph node yield was reported in 14 studies, with Yozgatli et al. and Ngu et al. demonstrating significantly higher numbers of lymph nodes harvested with a robotic approach compared to laparoscopic resection ($p < 0.05$) (33, 37).

Overall Morbidity & Mortality

Overall post-operative complication rates were reported in 9 studies. Similar morbidity rates were demonstrated between studies of 10% to 32% and 7% to 36% for RRH and LRH, respectively (table 3). No significant differences between overall complication rates were reported in any study. Mortality within the 30-day post-operative period was reported in 11 studies which ranged between 0% to 3.3% and 0% to 0.6% for robotic and laparoscopic approaches, respectively.

Discussion

This systematic review of 15 studies includes over 4000 patients undergoing laparoscopic and robotic right hemicolectomy for cancer. It highlights the positive impact of robotic surgery on components of successful patient orientated surgical outcomes at a relatively early stage since its inception. It is observed in this review that RRH is associated with significantly improved components of surgical outcomes when compared to LRH. Thirty-day morbidity and mortality was comparable in both approaches, with patients undergoing RRH having significantly lower anastomotic complications, length of stay, conversion to open, first flatus and incisional hernia rates in a number of studies. Post-operative ileus and wound infection rates were comparable between both approaches. Furthermore, in all key parameters measured throughout the review, LRH was never found to be significantly superior to RRH. No single study analysed all factors which authors associate with successful patient orientated surgical outcomes.

Most colorectal surgeons acknowledge the advantages of a robotic platform in rectal cancer surgery due to factors such as seven degrees of instrument manipulation, improved ergonomics and three-dimensional vision, but speculation and debate still exists for the routine use of robotics in right

sided colon malignancy. The main criticisms of RRH are longer operating times, loss of haptic feedback and notable trends of higher costs, though not significantly different, compared to laparoscopic right hemicolectomy (39-41). Within this study it was observed that RRH was associated with an increased operative time when compared to LRH. Increased operative time in RRH is influenced by a myriad of factors such as learning curve, set-up times, cart docking time, and the fact that many resections are performed with intracorporeal anastomosis (42, 43). This systematic review did not analyse operative time or costs however it is the author's experience that with increased caseload performance, the operative learning curve is reduced with docking times becoming more efficient and less time consuming. With regards to costs, we believe that initial increased set up costs and consumables are ultimately mitigated by less incisional hernia rates, decreased length of inpatient stay and anastomotic complications. It is understandable that performing an intra-corporeal anastomosis (ICA) will lengthen operative times, however it is felt that this increased operative time is negated by the fact that ICA is associated with less extraction site morbidity such as tractional haemorrhage, hernia and wound infection (44). Within this systematic review infection rates vary from 0 – 15% however there was no significant difference in wound infection rates in 10 studies following both approaches. A recent national surgical quality improvement project analysis in laparoscopic versus robotic colectomy in almost 26,000 colectomies highlighted that laparoscopic colectomy was associated with less post-operative sepsis compared to robotic approach (45). However, it was noted that less than 20% of the total cohort underwent right hemicolectomy within the study and post-operative sepsis was not clearly defined and used as a marker of generic infection at any site. A further study with a similarly large number of patients reported no significant difference in minor and major complications in laparoscopic versus robotic colectomy however robotic colectomy was significantly more expensive (\$17,445 vs \$15,448, $p=0.001$) (46). This study was limited due to the fact that only 2% of patients underwent robotic resection. Furthermore, the cost difference of \$2,003 would be offset by additional length of stay and subsequent cost of incisional hernia repair.

In this study, the incidence of incisional hernia following minimally invasive right hemicolectomy was only reported in 3 studies. Widmar et al. primarily examined the incidence of incisional hernias with follow up periods of 12 months following RRH and 30 months following LRH and demonstrated considerably higher rates of incisional hernias in LRH (32). It is well understood that patient and operative factors increase the potential risk of incisional hernia. ICA formation has been shown to reduce the risk of incisional hernia. In this current review, Morpugo et al. reported a significantly higher rate of incisional hernias following LRH with extracorporeal anastomoses (ECA) (8.3%) when compared with hybrid RRH with intracorporeal anastomoses (0%) (35). This finding was further compounded by a study analysing ICA versus ECA following right colectomy in obese patients displaying a significant increase in incisional hernia rate in the ECA group. A study examining the standardisation of specimen extraction in laparoscopic colorectal surgery reported an

incisional hernia rate of 15.3% in patients with a transverse muscle splitting incision (47). Moreover, the authors reported an early return to gut function in patients with ICA. With the aforementioned benefits of the robotic platform, it lends itself well to ICA formation with reduced learning curve and a decrease in overall associated complications compared to a laparoscopic approach (48). In this review only one study documented a significant increase in anastomotic leaks in patients undergoing laparoscopic ECA as opposed to robotic ICA (35). In addition, a propensity scored-matching study of robotic and laparoscopic formed anastomosis reported that minimally invasive ICA was associated with significant shorter hospital stay and lower complication rate after discharge to 30-days than ECA group (49). Similarly, this systematic review reports significantly lower hospital LOS in patients following RRH.

Post-operative ileus and passing of first flatus was analysed in this review. The incidence of ileus was similar between RRH and LRH, however in 4 studies passing of first flatus was reported to be significantly earlier in RRH (2.0 to 2.7 days v 2.5 to 4.0 days). This finding has been previously highlighted in studies with a meta-analysis analysing robotic versus laparoscopic approach in colonic resection for both cancer and benign diseases (50). Trastulli et al reported significantly less time to first flatus and reduced length of stay, post-operative complications and wound infections in the robotic colectomy cohort. Pathogenesis of post-operative ileus is multi-factorial involving disruption of sympathetic/parasympathetic pathways, inflammatory changes associated with GI dissection and manipulation and opioid use in the management of pain. Robotic surgery may allow more refined dissection and less mechanical traction on the gastrointestinal mesentery as compared to open and laparoscopic approaches thus reducing neuronal pathway disruption. Furthermore, with more precise dissection and reduced opioid use due to the minimal invasive nature and pivotal rather than tractional port manipulation associated with robotic dissection, all such factors are associated with reduced ileus and time to first flatus. Moreover, the development of enhanced recovery after surgery protocols (ERAS) in the last decade have altered the peri-operative management of such patients undergoing minimally invasive surgery with improved post-operative outcomes (51). Within this analysis two studies in particular, Scotton and Trastulli et al were early studies which recruited over a long study period. Despite having some elements of ERAS protocols in place it was not standardised throughout both study groups. Post-operative outcomes were found not to be inferior to more recent studies in the current analysis however the influence of such protocols was not primarily assessed.

Overall rates of conversion to open surgery were examined with reported rates ranging from 0% to 3.9% in RRH and 0%-18.1% in LRH. Three studies identified a significantly lower rate of conversion during RRH (28, 30, 36). This finding has been documented in many studies identifying a robotic approach to be significantly associated with lower conversion rates to open (52-54).

Furthermore, although examining outcomes in RRH compared to LRH for both oncological and benign lesions, a systematic review and meta-analysis by Solaini et al reported similar findings with

regards to conversion to open. A review of 11 studies which included 8257 patients reported a significant increase in conversion to open in patients undergoing LRH compared to RRH, however this was associated with increased cost. (55). The low conversion rates may be due to a multitude of factors such as improved three-dimensional visualisation, improved articulation, ergonomics and stabilised optics. This analysis highlighted similar morbidity between studies of 10% to 32% and 7% to 36% for RRH and LRH, respectively. Thirty-day mortality was also found to be comparable between both interventions.

The authors acknowledge that this review does have limitations. Firstly, due to the fact that non-English studies were omitted from analysis, varied sample size, unmatched cohorts and heterogeneity of some of the studies included can lead to publication bias. Additionally, due to the reduced number of randomised control trials and the lack of reporting of randomisation of patients to receive robotic intervention in certain studies is lacking and may represent selection bias. Furthermore, the authors acknowledge that the majority of the studies included do not comment on individual surgeon case load and outcomes attributed to using different robotic platforms. It is well recognized that there has been a continuous development of robotic systems during the study time period from the Da Vinci three arm standard to the more recent multi-quadrant Da Vinci Xi system and thus may influence patient outcomes in the RRH cohort over time. Finally, although outcomes on over 4000 patients were analysed this was represented by only fifteen studies due to strict inclusion criteria with no study reporting on all parameters of successful patient orientated surgical outcomes.

In conclusion, this systemic review highlights that minimally invasive approaches for right colectomy continue to evolve especially with an increasing number of centres embracing robotic surgery. In addition to being a safe and feasible approach for right hemicolectomy in cancer with comparable outcomes to established laparoscopic approach, RRH was associated with shorter length of stay, less conversion rates, reduced time to first flatus and decreased incisional hernia rates in a number of studies. Furthermore, as observed in this review that RRH is associated with significantly improved components of surgical outcomes when compared to LRH, it is the authors experience that intracorporeal anastomosis performed during RRH has a significant role to play in this. It is clear however that there is limited data on surgical approach and impact on quality of life and what patients deem successful surgical outcomes. There is a need for a randomised control trial examining successful patient orientated outcomes in minimally invasive surgical approaches to the right colon for malignancy.

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Table 1. Newcastle Ottawa Scale & Cochrane Risk of Bias Assessment

Newcastle Ottawa Scale Risk of Bias Assessment for Cohort Studies				
Study	Selection (Maximum = 4)	Comparability (Maximum = 2)	Outcome (Maximum= 3)	Overall Quality (Maximum = 9)
Cardinali et al. (52)	***	*	**	6
de'Angelis et al. (25)	***	*	***	7
Ferrara et al. (38)	***	*	**	6
Guerrieri et al. (34)	**	*	**	5
Haskins et al. (26)	***	*	**	6
Kang et al. (27)	***	*	***	7
Megevand et al. (28)	***	-	**	5
Morpugo et al. (35)	***	-	***	6
Ngu et al. (37)	***	**	**	7
Scotton et al.	***	*	***	7
Spinoglio et al. (30)	***	*	***	7
Trastulli et al. (31)	***	*	**	6
Widmar et al. (32)	***	*	***	7
Yozgatli et al. (33)	***	*	***	7
Cochrane Risk of Bias Tool for Randomised Controlled Trials				

Study	Random Sequence Generation	Allocation Concealment	Selective Reporting	Other Bias	Blinding of Participants or Personnel	Blinding of Outcome Assessment	Incomplete Outcome Data
Park et al. (29)	Low	Low	Low	Low	Unclear	Unclear	Low

Table 2. Study characteristics.

Authors	Pub Year	Study Type	Period	Aim	n = (RRH)	n = (LRH)	Anastomosis (n=)
Yozgatli et al. (33)	2019	Retrospective Cohort	2015-2017	Compare short term morbidity between RRH with CME vs conventional LRH	35	61	-
Haskins et al. (26)	2018	Retrospective Cohort	2012-2014	Compare pathologic results and 30-day morbidity/mortality between ORH vs LRH vs RRH	89	2405	-
Megevand et al. (28)	2018	Retrospective Cohort	2010-2015	Compare feasibility and safety of RRH with IA vs LRH with IA/EA	50	50	RRH IA (49); RRH EA (1); LRH IA (18); LRH EA (32)
Ngu et al. (37)	2018	Retrospective Cohort	2015-2017	Compare short term outcomes of RRH with IA vs LRH with IA	16	16	IA only
Scotton et al. (36)	2018	Retrospective Cohort	1998-2017	Confirm clinical advantages of RRH (hybrid/total robotic) with IA vs LRH with EA	206	160	RRH IA (206); LRH EA (160)
Spinoglio et al. (30)	2018	Retrospective Cohort	2005-2013	Compare safety and efficacy of RRH vs LRH with CME + IA	100	100	IA only
Cardinali et al. (52)	2016	Retrospective Cohort	2013-2015	Compare short term outcomes of RRH with IA vs LRH with EA	30	60	RRH IA (30); LRH EA (60)
de'Angelis et al. (25)	2016	Retrospective Cohort	2012-2015	Compare perioperative outcomes and costs of RRH vs LRH; also compare learning curve of RRH via operative times in a single surgeon	30	50	RRH - ; LRH EA (50)
Ferrara et al. (38)	2016	Retrospective Cohort	2008-2014	Compare short term outcomes of robotic vs laparoscopic colorectal resection with subset analysis of RRH vs LRH by a single surgeon	13	15	EA only
Kang et al. (27)	2016	Retrospective Cohort	2007-2011	Compare early perioperative/oncologic outcomes of ORH vs RRH vs LRH	20	43	EA only
Widmar et al. (32)	2016	Retrospective Cohort	2009-2014	Describe rates of incisional hernias and complications following RRH and LRH	69	207	RRH IA (11); RRH EA (58); LRH EA (207)

Guerrieri et al. (34)	2015	Retrospective Cohort	2013-2014	Compare benefits, short term outcomes and costs of robotic vs 3D laparoscopic colectomy with subset analysis of RRH vs LRH	18	11	RRH IA (14); RRH EA (4); LRH IA (4); LRH EA (7)
Trastulli et al. (31)	2015	Retrospective Cohort	2005-2014	Evaluate possible clinical advantages of RRH with IA vs LRH with IA vs LRH with EA	102	134	RRH IA (102); LRH IA (40); LRH EA (94)
Morpugo et al. (35)	2013	Retrospective Case Controlled	2008-2012	Evaluate clinical advantages of hybrid RRH with IA vs LRH with EA	48	48	RRH IA (48) LRH EA (48)
Park et al. (29)	2012	Prospective Randomised Clinical Trial	-	RCT comparing surgical outcomes and perioperative morbidity/mortality of RRH vs LRH	35	35	RRH IA (30); RRH EA (5); LRH IA (7); LRH EA (28)

RRH: Robotic Right Hemicolectomy; LRH: Laparoscopic Right Hemicolectomy; ORH: Open Right Hemicolectomy; RCT: Randomised Clinical Trial; IA: Intracorporeal Anastomosis; EA: Extracorporeal Anastomosis; CME: Complete Mesocolic Excision; “-”: not reported or not specified.

Study	Post Operative Ileus % (n)			Anastomotic Leak % (n)			Surgical Wound Infection % (n)			Median Length of Stay (days)			Incisional Hernia % (n)			Conversion to Open % (n)		
			<i>p-value</i>			<i>p-value</i>			<i>p-value</i>			<i>p-value</i>			<i>p-value</i>			<i>p-value</i>
	RRH	LRH		RRH	LRH		RRH	LRH		RRH	LRH		RRH	LRH		RRH	LRH	
Yozgatli et al. (33)	5% (2/35)	13% (8/61)	0.32	0% (0/35)	5% (3/61)	0.31	11% (4/35)	1% (1/69)	0.06	6	6	0.64	-	-	-	0% (0/35)	0% (0/61)	-
Haskins et al. (26)	12.4% (11/89)	9.8% (235/2405)	**	-	-	-	2.3% (2/89)	4.8% (115/2405)	0.17	4.4*	5.2*	**	-	-	-	-	-	-
Megevand et al. (28)	8% (4/50)	8% (4/50)	-	4% (2/50)	10% (5/50)	-	-	-	-	5	8	<0.001	-	-	-	0% (0/50)	14% (7/50)	<0.001
Ngu et al. (37)	-	-	-	-	-	-	-	-	-	4.5	4.5	0.402	-	-	-	-	-	-
Scotton et al. (36)	-	-	-	0.5% (1/206)	5% (8/160)	0.012	6.3% (13/206)	8.8% (14/160)	0.383	7.9*	9.9*	<0.001	1% (2/206)	2.5% (4/160)	0.41	2.4% (5/206)	18.1% (29/160)	<0.001
Spinoglio et al. (30)	10% (10/100)	10% (10/100)	-	1% (1/100)	1% (1/100)	-	5% (5/100)	10% (10/100)	-	7.9*	7.9*	0.948	-	-	-	0% (0/100)	6.9% (7/101)	0.04
Ferrara et al. (38)	-	-	-	0% (0/13)	13.3% (2/15)	-	-	-	-	7.1*	8.5*	0.26	-	-	-	-	-	-
Widmar et al. (32)	6% (4/69)	5% (10/207)	0.48	0% (0/69)	1% (1/207)	0.99	15% (10/69)	13% (26/207)	0.68	5	5	0.84	17% (12/69)	22% (46/207)	0.39	3% (2/69)	2% (4/207)	0.47
deÁngelis et al. (25)	3.3% (1/30)	0% (0/50)	0.375	0% (0/30)	4% (2/50)	0.525	-	-	-	7.1*	8.3*	0.133	-	-	-	0% (0/30)	4% (2/50)	0.525
Kang et al. (27)	0% (0/20)	2.3% (1/43)	0.262	-	-	-	0%	0%	-	8.5	9	**	-	-	-	0% (0/20)	2.3% (1/43)	1
Cardinali et al. (52)	0% (0/30)	1.7% (1/60)	-	0% (0/60)	1.7% (1/60)	0.62	10% (3/30)	1.7% (1/60)	-	6.8*	8.0*	0.125	-	-	-	3.3% (1/30)	8.3% (5/60)	0.66
Guerrieri et al. (34)	-	-	-	-	-	-	-	-	-	5*	5*	0.723	-	-	-	-	-	-
Trastulli et al. (31)	2% (2/102)	2.9% (4/134)	0.866	2.9% (3/102)	0% (0/134)	0.845	4.9% (5/102)	6.7% (9/134)	0.467	4	5.5	<0.0001	-	-	-	3.9% (4/102)	10.4% (14/134)	0.072
Morpugo et al. (35)	-	-	-	0% (0/48)	8.3% (4/48)	<0.05	10.4% (5/48)	14.6% (7/48)	-	7.5	9	<0.05	0% (0/48)	8.3% (4/48)	<0.05	-	-	-

Park et al. (29)	2.9% (1/35)	2.9% (1/35)	-	2.9% (1/35)	0% (0/35)	-	5.7% (2/35)	5.7% (2/35)	-	7.9*	8.3*	0.13	-	-	-	0% (0/35)	0% (0/35)	1
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Table 3. Right hemicolectomy primary endpoints.

* Study reports mean length of stay; ** Study reported statistically significant difference ($p<0.001$) between open and minimally invasive approaches (RRH/LRH) but did not directly compare RRH with LRH for the specific endpoint; “-“ not analysed or not reported; RRH: Robotic Right Hemicolectomy; LRH: Laparoscopic Right Hemicolectomy.

Table 4. Overall perioperative morbidity and 30-day mortality.

Study	RRH Complication % (n)	LRH Complication % (n)	p-value	RRH Mortality % (n)	LRH Mortality % (n)
Yozgatli et al. (33)	29% (10/35)	25% (15/61)	0.67	-	-
Haskins et al. (26)	-	-	-	1.1% (1/89)	0.3% (8/2405)
Megevand et al. (28)	-	-	-	0%	0%
Ngu et al. (37)	25% (4/16)	25% (4/16)	-	-	-
Scotton et al. (36)	-	-	-	0%	0.6% (1/160)
Spinoglio et al. (30)	27.7% (28/100)	33.6% (34/100)	0.36	1% (1/100)	0%
Cardinali et al. (52)	-	-	-	-	-
de'Angelis et al. (25)	13.3% (4/30)	20% (10/50)	0.499	3.3% (1/30)	0%
Ferrara et al. (38)	-	-	-	-	-
Kang et al. (27)	10% (2/20)	7% (3/43)	0.185	0%	0%
Widmar et al. (32)	32% (22/69)	34% (71/207)	0.71	0%	0%
Guerrieri et al. (34)	16.7% (3/18)	36.4% (4/11)	0.449	0%	0%
Trastulli et al. (31)	22.5% (23/102)	21.6% (29/134)	0.955	0%	0%
Morpugo et al. (35)	-	-	-	0%	0%
Park et al. (29)	17.1% (6/35)	20% (7/35)	0.500	0%	0%

RRH: Robotic Right Hemicolectomy; LRH: Laparoscopic Right Hemicolectomy; “-” overall morbidity/mortality rate specific to RRH/LRH not reported.

Figure 1: Study selection process.

Appendix 1 – Medline (OVID: 1946-present)

1. cancer.mp or exp Neoplasms/
2. malignancy.mp or exp Neoplasms/
3. carcinoma.mp or exp Carcinoma/
4. tumour.mp
5. 1 OR 2 OR 3 OR 4
6. exp Robotic Surgical Procedures/ or robot*.mp
7. “robot*”.m_titl.
8. 6 OR 7
9. exp laparoscopy/ or laparoscop*.mp
10. “laparoscop*”.m_titl.
11. 9 OR 10
12. exp Colectomy/ or right hemicolectomy.mp
13. right hemicolectomy.m_titl.
14. exp Colectomy/ or right colectomy.mp
15. right colectomy.m_titl.
16. 12 OR 13 OR 14 OR 15
17. 5 AND 8 AND 11 AND 16

Figure 1: Study selection process

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Title:

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Date:

2020-05-01

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