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Robotic right colectomy: A worthwhile procedure? Results of a meta-analysis of trials comparing robotic versus laparoscopic right colectomy

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Abstract

Background: Robotic right colectomy (RRC) is a complex procedure, offered to selected patients at institutions highly experienced with the procedure. It is still not clear if this approach is worthwhile in enhancing patient recovery and reducing post-operative complications, compared with laparoscopic right colectomy (LRC). Literature is still fragmented and no meta-analyses have been conducted to compare the two procedures. This work aims at reducing this gap in literature, in order to draw some preliminary conclusions on the differences and similarities between RRC and LRC, focusing on short-term outcomes. **Materials and Methods:** A systematic literature review was conducted to identify studies comparing RRC and LRC, and meta-analysis was performed using a random-effects model. Peri-operative outcomes (e.g., morbidity, mortality, anastomotic leakage rates, blood loss, operative time) constituted the study end points. **Results:** Six studies, including 168 patients undergoing RRC and 348 patients undergoing LRC were considered as suitable. The patients in the two groups were similar with respect to sex, body mass index, presence of malignant disease, previous abdominal surgery, and different with respect to age and American Society of Anesthesiologists score. There were no statistically significant differences between RRC and LRC regarding estimated blood loss, rate of conversion to open surgery, number of retrieved lymph nodes, development of anastomotic leakage and other complications, overall morbidity, rates of reoperation, overall mortality, hospital stays. RRC resulted in significantly longer operative time. **Conclusions:** The RRC procedure is feasible, safe, and effective in selected patients. However, operative times are longer comparing to LRC and no advantages in peri-operative and post-operative outcomes are demonstrated with the use of the robotic surgical system.

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Full Text

INTRODUCTION

Robotic surgical systems have several advantages over conventional laparoscopic instrumentations, including a third arm for fixed retraction, fine motion scaling, articulated instruments providing superior dexterity, a stable surgeon/controlled camera, and three-dimensional imaging. [1],[2] For these reasons, robotic minimally invasive surgery is particularly convenient for operations characterized by a small surgical field and high technical complexity, such as radical prostatectomy. [3] In the setting of colorectal surgery, the first successful robotic-assisted colorectal procedure involving colonic mobilisation of the right and sigmoid colon was reported in 2002. [4] Several reports have demonstrated the safety and feasibility of robotic colorectal procedures. [5],[6],[7],[8],[9] Rectal cancer surgery and other pelvic procedures, such as rectopexy, are particularly well suited for a robotic approach, for the small surgical field and the difficulty of retraction and visualisation. [10],[11] Several trials and two meta-analyses comparing robotic and laparoscopic rectal resection were published, showing a reduction of the conversion rate to open surgery for the robotic procedure. [12], [13] Whereas robotic rectal surgery was widely studied, only several single institution studies were reported on robotic right colectomy (RRC). [14] Laparoscopic right colectomy (LRC) is less complex than laparoscopic rectal resection; however, the robotic system may possibly be advantageous also for this technique, e.g. to perform an intra-corporeal 'hand-sewn' anastomosis.

No meta-analyses have been conducted comparing robotic with LRC; however, RRC is offered to selected patients at institutions highly experienced with the procedure. While several single institution retrospective studies comparing RRC with LRC have been conducted, these studies were limited by small sample sizes and their single institution design. Therefore, we conducted a systematic review of the literature and a meta-analysis of the selected studies to compare indications, surgical and oncologic outcomes, and costs of RRC versus those of LRC.

Materials and Methods

Study Selection

A systematic literature search was performed using Embase, Medline, Cochrane, and PubMed databases to identify all studies published up to and including January 2014 that compared RRC with LRC. The meta-analysis was conducted according the QUORUM guidelines. [15] The following Medical Subject Headings search headings were used: 'Robotic OR robot-assisted; laparoscopic; colectomy OR colic resection OR colon resection'. The 'related articles' function was used to broaden the search, and all abstracts, studies, and citations scanned were reviewed.

Inclusion Criteria

Studies included in our analysis were required to:

Compare characteristics and peri-operative outcomes of patients undergoing RRC and LRC, and Involve a previously unreported patient group (if patient material was reported more than once by the same institution, the most informative and recent article was included in our analysis).

We excluded studies in which the operation was started by laparoscopy and continued with the robot to perform the anastomosis.

Exclusion Criteria

The following types of studies were not considered for inclusion in our meta-analysis:

Studies in which the outcomes of interest (specified later) for both robotic and laparoscopic techniques were not reported or were impossible to calculate; 'How I do' articles, animal studies, case reports, and non-English language studies, studies on national databases.

Quality Assessment

All selected non-randomised studies were reviewed for methodological quality by three reviewers, according to the Newcastle-Ottawa Scale for non-randomised studies, [16] and to the Jadad scale for randomised controlled trials (RCT). [17] Final scores were reached by general consent.

Data Extraction

Two reviewers independently extracted the following information from each study: First author, year of publication, study population characteristics, study design, indications for operation, number of subjects who underwent an operation with each technique, rate of conversion from a minimally invasive to an open technique or hand-assisted technique, surgical techniques, and peri-operative outcomes.

Outcomes of Interest and Definition

All studies were abstracted for the following relevant data: Patient baseline characteristics (age, sex, body mass index [BMI], American Society of Anaesthesiologists [ASA] Score), tumour characteristics (malignant histology, T, N), type of procedure (RRC, LRC), technique of ileocolic anastomosis, operative outcomes (operative time, intraoperative blood loss, and conversion to hand-assisted or open surgery), extension of lymphoadenectomy, resection margins, post-operative recovery time (duration of hospital stay), reoperation rate, and post-operative complications (morbidity and mortality), costs.

Statistical Analysis

Statistical analyses and meta-analysis were performed using MedCalc for Windows, version 10.2.0.0 software (MedCalc Software, MariaKerke, Belgium).

The Mantel-Haenszel method was used for calculating the weighted summary odds ratio (OR) under the fixed effects model and the heterogeneity statistic (I2) was incorporated to calculate the summary OR under the random-effects model. The total OR with 95% confidence interval (CI) is given both for the fixed effects model and the random-effects model. If the value 1 is not within the 95% CI, then the OR is considered to be statistically significant at the 5% level ($P < 0.05$).

For meta-analysis of studies with a continuous measure (comparison of means between treated cases and controls), the Hedges g statistic was used as a formulation for the standardised mean difference (SMD) under the fixed effects model. Next, the heterogeneity statistic was incorporated to calculate the summary SMD under the random-effects model. If the value 0 is not within the 95% CI, the SMD is considered to be statistically significant at the 5% level ($P < 0.05$).

Statistical heterogeneity of trial results was assessed on the basis of a test for heterogeneity (standard Chi-squared test on N degrees of freedom, where N equals the number of trials contributing data minus one). Three possible causes for heterogeneity were pre-specified:

Differing response according to a difference in trial quality;Differing response according to sample size; Differing response according to clinical heterogeneity.

If the test for heterogeneity was statistically significant ($P < 0.05$), greater emphasis was placed on the random-effects model.

RESULTS

Six studies comparing RRC and LRC, and published between 2009 and 2013, were included in our meta-analysis.(18-23) Characteristics of the study and quality assessments are reported in [Table 1]. One report [18] was a RCT including 70 patients undergoing RRC (35 patients) and LRC, [19] whereas the others were retrospective studies. The meta-analysis included a total of 168 patients who underwent RRC and 348 patients who underwent LRC.{Table 1}

Clinical, Pathologic and Operative Characteristics

The patients in the two groups were similar with respect to proportion of male patients (OR = 0.985; 95% CI = 0.618-1.572), BMI (OR = −0.119; 95% CI = −0.493-0.255), presence of malignant disease (OR = 0.765; 95% CI = 0.472-1.239), previous abdominal surgery (OR = 1.284; 95% CI = 0.466-3.543). The two groups showed differences in terms of age (SMD = −0.165; 95% CI = −0.535-0.206), and ASA score (OR = 1.046; 95% CI = 0.470-2.327), with younger patients and higher proportion of ASA 1 and 2 in the robotic group [Table 2].{Table 2}

Peri- and Post-operative Outcomes

The peri-operative and post-operative outcomes of the two types of procedures are shown in [Table 3]. There were no statistically significant differences between RRC and LRC regarding overall morbidity, development of anastomotic leak, wound infection, intra-abdominal infection, or rates of reoperation and overall mortality.{Table 3}

Compared to LRC, use of RRC resulted in significantly longer operative time (SMD = 0.928; 95% CI = 0.309-1.548) [Figure 1], whereas estimated blood loss was similar (SMD = −0.634, 95% CI = −0.948-0.319). Rates of conversion to open surgery were similar [Figure 2]. The number of retrieved lymph nodes was similar between the two groups (SMD = 0.0177, 95% CI = −0.423-0,459). Furthermore, hospital stay was not significantly different (SMD = −0.0858, 95% CI = −0.442-0.270). Total costs were reported by two authors. Costs analysis showed a trend toward augmented costs for RRC (SMD = 0,713, 95% CI = −0.0743-1.501), which was however not significant (P = 0.0693). Meta-analysis diagram for overall complications is reported in [Figure 3].{Figure 1}{Figure 2}{Figure 3}

DISCUSSION

The evolution of minimally invasive techniques represents one the most important advances in abdominal surgery during recent decades. Laparoscopic surgery have improved patient recovery compared with 'traditional' open surgery, with relevant gains in terms of reductions in post-operative pain, morbidity, and length of hospitalisation comparing to open surgery. [20],[21],[22] The robotic surgical system was then developed with the following objective: Enhance comfort and surgeon dexterity and ensure minimal surgical trauma such as with laparoscopic surgery. [23] Indeed, the robotic system has the following main practical advantages compared with traditional laparoscopic instrumentation: A fine motion scaling, a surgeon controlled camera, a third arm for retraction, and a better image.

The first robotic procedure that achieved widespread use was radical prostatectomy; [24] in the setting of abdominal surgery almost all procedures have been performed via the robotic surgical system. [25],[26] The first meta-analytic studies comparing robotic and laparoscopy for abdominal procedures were published very recently, in the last few months. Regarding open gastrectomy, a reduction in intraoperative blood loss and post-operative hospital length of stay compared with laparoscopic gastrectomy and open gastrectomy at a cost of a longer operating time was observed. [27] Robotic adrenalectomy provided potential advantages of a shorter hospital stay, less blood loss, and lower occurrence of post-operative complications compared to laparoscopic surgery. [28] Robotic Roux-en-Y gastric bypass had similar complication rates but higher costs comparing to laparoscopic bypass. [29]

In the setting of robotic colorectal surgery, the majority of studies concerned rectal surgery, which is a good indication for the robotic approach for the small surgical field, the necessity of nerve preservation, and the complex technique, such as radical prostatectomy. [30] Meta-analyses of studies comparing robotic versus laparoscopic rectal resection showed several potential advantages for the robotic groups: Reduced estimated blood loss and a lower intraoperative conversion rate, with no differences in complication rates and surrogate markers of successful surgery; [19] reduced conversion rate to open surgery. [31],[32],[33]

Right colectomy is a less technically demanding procedure comparing to rectal resection. LRC is already widely diffused and provides several well-known advantages compared to open right colectomy: Reduction of post-operative complications, blood loss, hospital stay, [34] faster recovery, lower rate of wound infection. [35] Whereas robotic rectal surgery has been well analysed, [36] only few single institutional studies were published comparing laparoscopic versus RRC, with controversial results. Some authors suggest that the robotic approach has potential advantages in terms of less post-operative length of stay and less peri-operative complications. Others, instead, suggest that the robot may not provide additional benefits. [37] In view of this background, we designed a meta-analysis of studies comparing laparoscopic versus RRC, in order to draw some preliminary, but consistent conclusions, on the basis of the early literature on the issue. The main objective of the study was to compare the short term outcomes: Does robotic surgery provide any peri-operative and post-operative advantage over laparoscopic surgery in the setting of right colectomy?

Our meta-analysis included 6 comparative studies (one was a randomized trial) conducted at well-known institutions with high levels of experience in both laparoscopic and robotic colorectal surgery. [18],[38],[39],[40],[41],[42]

The pre-operative characteristics of patients who received RRC or LRC were similar: No significant differences were detected in sex, BMI, or histological diagnosis, and in the majority of cases, RRC and LRC were used for resection of malignant disease. However, a significant difference was identified between the two groups in our meta-analysis regarding age and ASA score, with younger patients and patients with lower ASA score in the robotic group. Clearly, robotic surgery was preferentially offered to selected young and 'healthy' patients. No information was reported regarding tumours' size.

Comparison of peri-operative outcomes showed no differences in estimated blood loss and conversion to open surgery. However, a significant difference was detected in operative time, which was longer for the robotic group ($P = 0.0004$). Overall and specific complications and mortality were similar between the two groups, and also post-operative length of stay was comparable. Oncological outcomes for the two groups of patients were not calculated, because all of the included studies focused on short term results, and no data concerning long-term survival were reported. However, the number of retrieved lymph nodes (which is a parameter linked to the oncological accuracy of the surgical procedure) was similar. Costs were reported only by two authors, and were not significantly different, but a trend versus higher costs was noted for the robotic group ($P = 0.0693$).

The results of this meta-analysis of 6 comparative studies did not show significant advantages with the use of the robotic system for right colectomy. Even if the patients in the robotic group were younger and 'more healthy' (lower ASA scores), short-term results were comparable to those obtained in the laparoscopic group. Furthermore, operative time was significantly longer in the robotic group and a trend for higher costs (even if not significant) was observed.

For several reasons, the results of our meta-analysis should be interpreted with caution. First, only one of the 6 included studies was a RCT, the only RCT that was published on this topic. Another possible limitation of our analysis is publication bias, which may lead to preferential reporting of positive and optimistic results regarding a new technique such as RRC. However, one bias against RRC is that the majority of the procedures represented initial series, and greater experience with the technique may produce better results. Another factor that was not addressed in our meta-analysis (because no relevant data were reported) is the long-term oncologic outcome of RRC for colon cancer. Costs were reported only by two studies and were higher in the robotic group, even if a significant difference was not demonstrated, probably for the small sample size. Further analyses should focus on this important aspect, and also on the costs linked to increased operative time, which are centre dependent and based on personnel remuneration, overhead costs, and time between operative cases.

CONCLUSION

Our meta-analysis shows that RRC is a feasible and safe technique when performed at highly selected expert institutions. When compared to LRC, use of RRC did not result in better short-term outcomes or in reduced complications or conversion rates. Use of RRC resulted in a significantly increasing of operative time and a trend for increased costs.

Additional studies are needed to investigate the long-term oncologic outcomes associated with use of RRC in the setting of colic neoplasms, and to better assess the costs associated with the procedure. Ideally, these types of findings should be validated by a randomised trial comparing RRC and LRC. However, in the absence of such data, we believe that at present RRC has still not demonstrated consistent advantages comparing to LRC, and may be reserved only to selected patients at experienced medical centres. It is possible that the improvement of surgical experience and technology and the reduction of costs may enhance the outcomes of RRC, but at present LRC is still more convenient in terms of operative times and guarantees short term results comparable to those of RRC.

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