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Simultaneous Robot Assisted Colon and Liver Resection for Metastatic Colon Cancer

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ABSTRACT

Introduction: Simultaneous robot assisted colon and liver resections are being performed more frequently at present due to the expanded adoption of the robotic platform for surgical management of metastatic colon cancer. However, this approach has not been studied in detail with only case series available in the literature. The aim of this systematic review was to evaluate the current body of evidence on the feasibility of performing simultaneous robotic colon and liver resections.

Methods: A systematic review was performed through PubMed to identify relevant articles describing simultaneous colon and liver resections for metastatic colon cancer.

Results: A total of 28 patients underwent simultaneous resections robotically with an average operative time of 420.3 minutes and average blood loss of 275.6 ml. Postoperative stay was 8.6 days on average with all cases achieving negative surgical margins.

Conclusions: Robotic simultaneous resection of colorectal cancer with liver metastases is technically feasible and seems oncologically equivalent to open or laparoscopic surgery. Further studies are urgently needed to assess benefits of robotic surgery in the patient population.

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INTRODUCTION

Colorectal cancer (CRC) is among the most common causes of cancer related deaths worldwide, and in particular metastatic disease. The most common site of CRC metastasis is the liver[1] accounting for up to 25% of patients with CRC.[2,3] Liver resection is seen as the only way to achieve cure. Unfortunately, it is not possible in about 25% of cases due to an inadequate liver remnant, number of metastases, or the presence of extra-hepatic disease. Right-sided colon cancer often leads to a higher number of liver metastases and a worse overall survival when compared to left-sided colon cancer.[4]

In the age of minimally invasive surgery, laparoscopic simultaneous colonic and hepatic resections for stage IV CRC have become possible. Several studies have shown that laparoscopic simultaneous resection of a primary tumor and hepatic metastatic lesion is safe, feasible, and favorable when compared with open approaches with comparable oncological outcomes.[5–8] Moreover, additional reported benefits of this procedure include the following: quicker postoperative intestinal recovery, improved morbidity, decreased length of hospital stay, reduced blood loss and reduced surgical access trauma.[9–11] In addition, simultaneous surgical resections allow for less health care resource utilization as compared with staged operations.[12]

There is insufficient evidence evaluating simultaneous hepatic and colon resections for stage IV CRC as compared to staged procedures. There is, however, evidence that robotic surgery offers many advantages over laparoscopic surgery for both colorectal resections and hepatectomies. The benefits of the robot with improved visualization and ability for wrist motion is offset by the time needed for docking, lack of haptics, and possible need for redocking due to multi-quadrant surgery. With the need for redocking of the robot for multi-quadrant surgery, the benefits of robotic surgery over laparoscopic approach is not known.

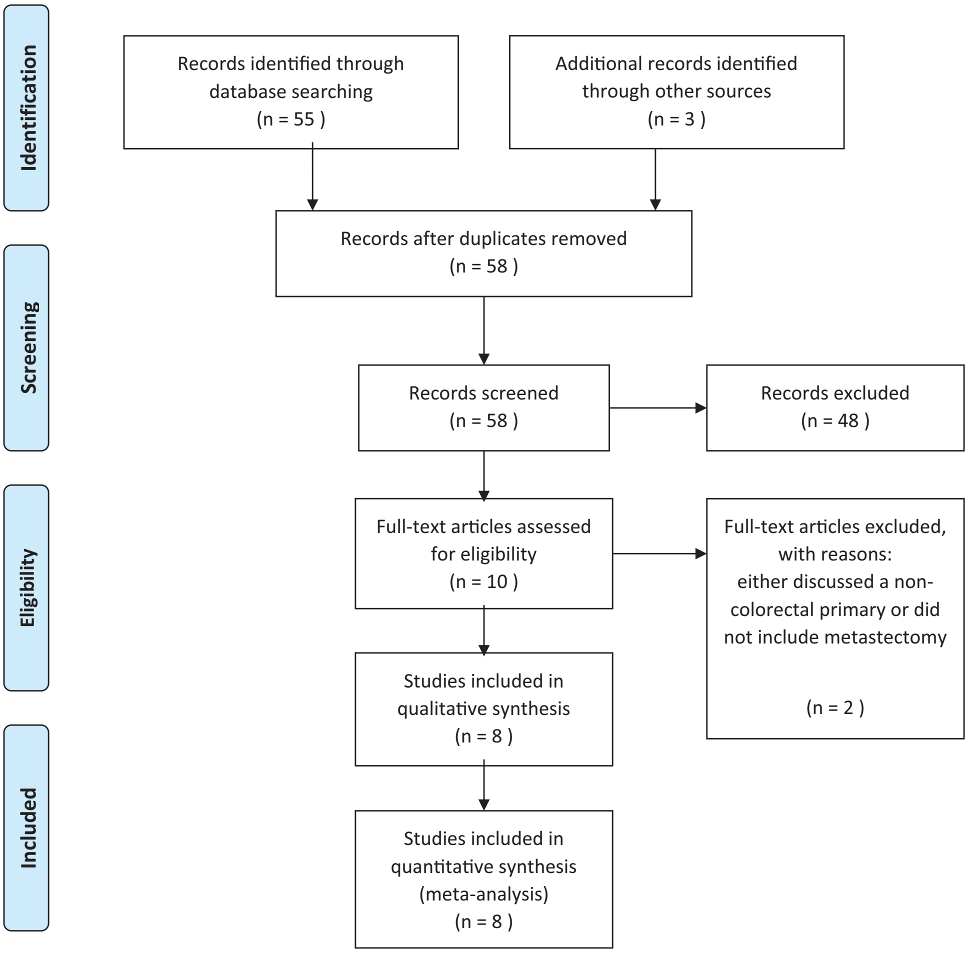

Figure 1. PRISMA study inclusion flow diagram.[44]

The aim of this review was to evaluate the current body of evidence in order to assess the feasibility of performing simultaneous robotic resections.

METHODS

Search Strategy and Eligibility Criteria

The literature search, data retrieval, and analysis, followed by critical appraisal, were performed by two independent researchers (MM and MG). Any disagreements occurring during the process were discussed with the senior author (XDD) and resolved. PubMed was systematically searched using the following medical subject headings (MeSH) terms: 'robot,' 'colon,' 'liver,' combined with the Boolean operator 'AND' and all synonyms combined with the Boolean operator 'OR'. Inclusion criterion was any paper reporting on simultaneous robotic colon and liver surgery for CRC with liver metastasis. Relevant articles were identified, and the results of the search were screened through the title, abstract, and/or full text article. The details of the literature search and study selection can be seen in **Figure 1**. The literature search yielded a total of 55 articles and 3 additional papers were found through the references in the articles included. These 58 records were screened through titles and abstracts, of which 10 were considered eligible for inclusion. The full text of these 10 articles was screened, after which 2 were excluded due to the fact that they either discussed a non-colorectal primary cancer or did not include metastasectomy.[13,14]

Data Collection

The data from the included articles were collected into prespecified tables in Microsoft Excel. Collected data included demographics, clinical presentation, and perioperative outcomes. We attempted to contact the authors of the articles included in order to add details such as docking and surgeon console times, resection margins, anastomotic technique, and daVinci® robot platform (S vs. Si vs. ξ).

Statistical Analysis

Statistical analysis was performed using SPSS Software (Version 26; SPSS Inc., Chicago, IL, USA). Continuous variables were expressed in means, whereas categorical variables were expressed in percentages. A pie chart was constructed, breaking down the different types of hepatectomy performed.

Table 1.
Continuous Variables for Patients Undergoing Simultaneous Robotic Colon and Liver Resections for Stage IV Colorectal Cancer

Continuous Variables	
Characteristic	Mean
Age (years)	62.5
BMI (kg/m^2)	22.4
Operative time (minutes)	420.3
Estimated blood loss (mL)	275.6
Length of stay (days)	8.6
Follow up (months)	15.1

BMI, body mass index.

RESULTS

Demographics

There were 28 patients included in this review from 8 different articles. The mean age was 62.5 years old, with 46.4% being female (**Table 1**, **2**). The mean body mass index was 22.4 (**Table 1**). Of the 28 patients, 10 had a single hepatic metastasis, while 7 had multiple metastatic lesions, while 11 did not mention the number of metastatic lesions (**Table 2**). In the paper by Dwyer, there was an average of 2.25 liver segments resected. Of those recorded, there were 3 metastatic lesions in the right liver, 4 in the left liver, and 3 that involved both the right and left liver.[15–22]

Intra-Operative Outcomes

The average operative time for the patients studied was 420.3 minutes (**Table 1**). For the liver resections, there were several methods of metastasectomy. There were 8 wedge resections, 9 segmentectomies, 3 bisegmentectomies, 1 trisegmentectomy, 3 hemihepatectomies, 1 left lateral sectionectomy, and 1 caudate lobectomy (**Table 1**). During the operations, there was an average blood loss of 275.6 milliliters (**Table 1**). All cases were done robotically and none required conversion to laparoscopic or open procedures. There were no intra-operative complications reported (**Table 2**).

Post-Operative Outcomes

Following their procedures, patients stayed on average 8.6 days in the hospital (**Table 1**). There were 8 total

Table 2.
Categorical Variables for Patients Undergoing Simultaneous Robotic Colon and Liver Resections for Stage IV Colorectal Cancer

Categorical Variables	
Characteristic	N (%)
Gender	
Male	15 (53.6)
Female	13 (46.4)
Number of metastases	
Single	10 (35.7)
Multiple	7 (25)
Not specified	11 (39.3)
Liver resection	
Wedge	8 (30.8)
Segmentectomy	9 (34.6)
Bisegmentectomy	3 (11.5)
Trisegmentectomy	1 (3.8)
Hemihepatectomy	3 (11.5)
Left lateral sectionectomy	1 (3.8)
Caudate Lobectomy	1 (3.8)
Conversion to open	0 (0)
Conversion to laparoscopic	0 (0)
Outcomes	
Intra-operative complications	0 (0)
Postoperative complications	8 (28.6)
Mortality	1 (3.6)

postoperative complications; 2 superficial surgical site infections, 1 anastomotic leak, 2 liver abscesses, 1 had postoperative ascites, 1 required intensive care unit admission post-op, and 1 postoperative ileus (**Table 2**). Patients were followed for an average of 150.1 months (**Table 1**). There was one mortality in this group, with 1 patient dying at 26 months due to their colorectal cancer (**Table 2**). Of the cases where it was recorded, all cases were able to achieve both a hepatic and colorectal resection with clear margins.

DISCUSSION

Robotic surgery has seen tremendous growth over the last decade. Complex oncologic surgeries are increasingly being performed robotically with increasing surgeon comfort with the approach. However, both short-term and long-term data are sparse on multivisceral robotic surgeries because of the need to dock the robot and time constraints from the robotic approach. Metastatic colon cancer with need for concurrent colon and liver resection is the ideal surgery to demonstrate feasibility of the robotic approach for complex oncologic operations needing multiquadrant dissection and approach. To date, concrete evidence supporting robotic approaches for concurrent liver and colon resection is lacking.

As robotic surgery becomes more common, many studies have demonstrated advantages of robotic surgery for both isolated colorectal or hepatic resections. In a meta-analysis of robotic vs. laparoscopic colectomies, Chang et al. found a significantly lower complication rate (odds ratio [OR]: 0.78, $P \leq .001$), less blood loss (mean deviation [MD]: -19.24, $P \leq .001$), and no significant differences in lymph nodes extracted (MD: 49.25, $P \leq .001$).[23] Duan et al. also showed a lower blood loss, lower intra-operative conversion rate, shorter hospital length of stay, and lower postoperative complication rates for robotic colectomy.[24] Scotton et al. found significantly less conversions to open surgery (20.4% vs. 180.1%, $P \leq .001$), less anastomotic leaks (00.5% vs. 5%, $P = .012$), and decreased bleeding (00.3% vs. 40.4%, $P = .024$) in patients undergoing robotic colectomies.[25] In comparing robotic to laparoscopic and open hepatectomies, Cortolillo et al. found that the robotic cohort had a lower mean cost of index admission ($24,983 vs. $32,391 in open, $P \leq .01$), a shorter length of stay (4.5 vs. 6.8 in laparoscopic vs. 7.6 in open, $P \leq .01$), and a lower 45-day readmission rate (7.9% in robotic vs. 13.0% in laparoscopic vs. 13.8% in open, p-0.05).[26] However, operating time is typically longer in robotic surgery, due to the constraints caused by docking and range of motion for the robotic arms.[23–25,27] Going a step further, Garritano et al. pooled simultaneous minimally invasive procedures, both laparoscopic and robotic, and found this approach to be safe.[28]

We have reviewed the available literature describing the feasibility of simultaneous robot assisted colon and liver resections. The pooled operating time across these included reports was 420.3 minutes. This was similar to the operating times reported in the literature for simultaneous laparoscopic resection. The average time for Zhu et al. was 320 minutes.[9] There was a median operating time of 360 minutes found by Ferretti et al.[5] Jaeck et al. found an operating time of 331 minutes, while Polignano et al. reported this to be 370 minutes.[8,10] Spampinato et al. found a median operating time of 495 minutes in 2013, while Inoue et al. reported this to be 452 minutes.[6,7] Overall, it appears that robotic simultaneous resection is feasible in terms of operating time. Although the finding of this review is in line with previous publications and the operating time of laparoscopic surgery, one can argue that 420.3 minutes may be longer than expected. This may be explained by the fact that not only wedge resections, but anatomic hepatectomies, were performed in the included studies. A similar reasoning can explain the longer length of stay in such patients. None-the-less, length of stay is a variable that is dependent on many different factors, including those not related to patients' health.

Though the pooled operating time found in this review was slightly higher than that reported in previous studies on simultaneous laparoscopic resection, robotic surgery may have the benefit of a shorter learning curve. In fact, operating times have been previously shown to decrease with proficiency, with robotic surgery possibly having a shorter learning curve as compared to laparoscopic surgery.[29–32] If these cases become more common, the operating time will likely decrease, making such procedure even more feasible.

Another important finding of this review was that resection margins were reported to be uninvolved in all included cases. Robotic colorectal cancer surgery was previously found to be associated with similar margins and higher number of lymph nodes harvested as compared to laparoscopic surgery.[33,34] Such acceptable (if not better) histopathological outcomes in this group of patients may indicate that simultaneous robotic resections are safe in addition to being feasible.

It is noteworthy that none of the patients undergoing robotic simultaneous resection required conversion to laparoscopic or open surgery. It is well known that conversion from minimally invasive to open surgery is associated with worse outcomes, namely increased rates of infection, cardiac complications, ileus, reoperation, longer length of stay, and higher overall costs.[35–38] Robotic colectomies are associated with a lower risk of conversion to open surgery as compared to laparoscopic colectomies, which provides another benefit of simultaneous resection performed robotically.[39–43]

The strength of this review is the fact that there are currently few published reviews of the literature on simultaneous robotic resections for colorectal cancer with liver metastasis.

Some limitations of this study do exist. Only case reports and case series were included in this review as no higher evidence, better design, or larger samples was available in the literature. Therefore, the total number of patients whose data were synthesized was limited. Another limitation was an overall lack of important details in different papers, such as the docking time and surgeon console times, anastomotic type, and robotic platform utilized. An attempt to reach out to corresponding authors was unsuccessful.

CONCLUSION

Robotic simultaneous resection of colorectal cancer with liver metastases seems to be technically feasible and oncologically safe. Current evidence is limited to case reports and case series, not allowing for robust conclusions. Lack of observational studies comparing simultaneous to staged procedures of interest does not currently allow suggesting sound clinical and scientific implications. Further descriptive and/or comparative reports are necessary for better understanding of the pros and cons of as well as indications for simultaneous robotic colon and liver resection of metastatic colorectal cancer.

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