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## Procedure-Specific Risks of Robotic Simultaneous Resection of Colorectal Cancer and Synchronous Liver Metastases

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### Abstract

An estimated 25% of patients with colorectal cancer (CRC) present with distant metastases at the time of diagnosis, the most common site being the liver. Although prior studies have reported that a simultaneous approach to resections in these patients can lead to increased rates of complications, emerging literature shows that minimally invasive surgical (MIS) approaches can mitigate this additional morbidity. This is the first study utilizing a large national database to investigate colorectal and hepatic procedure-specific risks in robotic simultaneous resections for CRC and colorectal liver metastases (CRLM). Utilizing the ACS-NSQIP targeted colectomy, proctectomy, and hepatectomy files, 1,721 patients were identified who underwent simultaneous resections of CRC and CRLM from 2016–2021. Of these patients, 345 (20%) underwent resections by an MIS approach, defined as either laparoscopic (n=266, 78%) or robotic (n=79, 23%). Patients who underwent robotic resections had lower rates of ileus compared to those who had open surgeries. The robotic group had similar rates of 30-day anastomotic leak, bile leak, hepatic failure, and post operative invasive hepatic procedures compared to both the open and laparoscopic groups. The rate of conversion to open (8% vs. 22%, p=0.004) and median LOS (5 vs. 6 days, p=0.022) was significantly lower for robotic compared to laparoscopic group. This study, which is the largest national cohort of simultaneous CRC and CRLM resections, supports the safety and potential benefits of a robotic approach in these patients.

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#### Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Shannon N. Radomski, Sophia Y. Chen, Miloslawa Stem, and Joy Zhou Done. The first draft of the manuscript was written by Shannon N. Radomski, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

#### Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

#### Ethics approval

This is an observational study. The Johns Hopkins Hospital IRB has confirmed that no ethical approval is required.

## Keywords

robotic surgery; colorectal liver metastases; simultaneous resections; hepatic resection

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## INTRODUCTION

Approximately 20–25% of patients with colorectal cancer (CRC) present with metastatic disease at the time of diagnosis [1]. For patients with resectable colorectal liver metastases (CRLM), surgical resection is the preferred treatment modality with a 5-year overall survival (OS) rate of 38% and median OS of 3.6 years [2]. Resections can be performed in a simultaneous or staged fashion, although there is no clear consensus on the optimal approach. The decision is based on a variety of complex factors including patient comorbidities, timing and regimen of chemotherapy, and concern for potential delays in the delivery of systemic treatment and cancer progression due to extended recovery periods after surgery. Recent case reports and institutional series have reported on the benefits of minimally invasive liver surgery (MILS) in simultaneous resections, including decreased length of stay (LOS), rates of conversion to open, and blood loss, as well as similar overall hospital costs compared to an open approach [3–8]. The aim of this study was to report on procedure-specific outcomes of robotic simultaneous CRC and CRLM resections from a national database.

## METHODS

Adult patients with CRC who underwent simultaneous colorectal and liver resections between 2016 and 2021 were identified from the colectomy, proctectomy, and hepatectomy-targeted American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) files. Further stratifications were made based on operative approach (laparoscopic, robotic, or planned open) and risk of procedure. Consistent with prior risk stratifications reported in the literature patients were divided into high-risk or low-risk groups based on the overall 30-day postoperative morbidity of the procedures performed [9]. High risk colorectal procedures were defined as those having ≥35% morbidity rate for open procedures and ≥25% morbidity rate for MIS procedures (due to the lower overall morbidity associated with MIS colorectal procedures). High risk hepatic procedures were defined as those having ≥35% morbidity rate for open and MIS procedures. A simultaneous procedure was considered high risk if either the colorectal or hepatic resection was high risk.

The primary outcomes were procedure-specific 30-day postoperative complications. This was defined as postoperative ileus and/or anastomotic leak for colorectal procedures; and liver failure, bile leak, and/or the need for a second invasive hepatobiliary intervention (such as percutaneous drain placement) for hepatic procedures. Secondary outcomes included an unplanned conversion to open procedure and 30-day postoperative overall morbidity, serious morbidity, readmission, reoperation, mortality, and LOS. Overall morbidity was defined as the occurrence of one or more of the following adverse events: wound infection, pneumonia, urinary tract infection (UTI), venous thromboembolism (VTE), cardiac complication, shock/sepsis, unplanned intubation, bleeding requiring transfusion, renal complication, on

ventilator >48 hours, and organ/space surgical site infection (SSI). Serious morbidity was defined based on Clavien-Dindo class III-IV (cardiac or renal complications, shock/sepsis, unplanned intubation, on ventilator >48 hours, organ/space SSI, or reoperation). This study was approved by the Institutional Review Board of the Johns Hopkins School of Medicine.

## RESULTS

A total of 1,721 patients were identified who underwent a simultaneous resection. Of these patients, 345 (20%) underwent resection by an MIS approach, defined as an intended laparoscopic (n=266, 77%) or robotic procedure (n=79, 23%). A planned open approach was utilized in 1,376 (80%) patients. Patients who underwent robotic surgery were younger (median: 52 vs. 63 years,  $p<0.001$ ), had a higher ASA classification (class I/II/III/IV (%): (1/34/62/3 vs. 0.4/21/70/8.3),  $p=0.034$ ), and more frequently received preoperative chemotherapy (68% vs. 55%,  $p=0.038$ ) than patients who underwent laparoscopic surgery. The majority of simultaneous procedures were considered low risk regardless of operative approach (open: 75%, robotic: 90%, laparoscopic: 87%).

Colorectal-specific outcomes were available for 705 patients (41%) while hepatectomy-specific outcomes were available for 1,016 patients (59%). Patients who underwent robotic resections had lower rates of ileus compared to the open group but similar rates to the laparoscopic group (Table 1). There were no differences in rates of 30-day anastomotic leak among robotic, laparoscopic, and open approaches. No hepatobiliary-specific complications occurred in patients undergoing a robotic hepatectomy.

The rate of unplanned conversion to open was lower for robotic compared to laparoscopic cases (8% vs. 22%,  $p=0.004$ ). Rates of 30-day postoperative overall morbidity (25% vs. 32%,  $p=0.287$ ), serious morbidity (9% vs. 16%,  $p=0.105$ ), readmission (8% vs. 9%,  $p=0.623$ ), reoperation (4% vs. 4%,  $p=0.894$ ), and mortality (1% vs. 2%,  $p=0.877$ ) did not differ between the robotic and laparoscopic groups. Median LOS (5 days [IQR:4–6] vs. 6 days [IQR: 4–8],  $p=0.022$ ) was shorter for the robotic surgery group.

## DISCUSSION

Advances in comprehensive cancer care and a greater emphasis on a multidisciplinary approach have led to increased treatment options for patients presenting with resectable CRLM. Surgical resection is the preferred definitive treatment; however, data on procedure specific post operative complications following a simultaneous versus staged approach is lacking. Although prior reports have utilized the NSQIP database to investigate the overall morbidity of simultaneous resections, this is the first national report to 1) specifically investigate outcomes of robotic resections, and 2) compare colorectal and hepatectomy-specific risks between the open, laparoscopic, and robotic surgical groups. Our report found that although the number of reported robotic resections was small (n=79), rates of ileus, anastomotic leak, bile leak, hepatic failure, and need for invasive hepatic procedures post operatively were low, and rates of conversion to open and median LOS were superior for robotic compared to laparoscopic cases.

Prior reports that utilized NSQIP to investigate the morbidity of a simultaneous versus staged approach primarily included patients who underwent open surgeries [9,10]. Reports of MILS in simultaneous resections are currently limited to case series and small single-institutional studies. A systemic review of 9 studies investigating robotic assisted simultaneous resections for patients with synchronous CRC and CRLM included a total of 29 patients and found the overall rate of any morbidity was 38%, the rate of serious morbidity was 7%, and no perioperative deaths or conversion to open were noted [3]. 10% of patients experienced liver related complications, and only one patient experienced a colorectal complication (anastomotic leak); however, there was no comparison to rates from laparoscopic cases. The most recent institutional report by Shapera et al. found that in a cohort of 26 patients (20 robotic) who underwent simultaneous CRC and CRLM resections, there were no unplanned conversions to open, and the rate of serious morbidity was 10%, despite the fact that the majority of patients underwent major liver resections (62%) [8]. Compared to single institutional studies, there is likely significant heterogeneity in patient care practices and operative techniques among the centers included in our analysis. One example of this may be differences related to the administration of neoadjuvant chemotherapy. In our cohort, there were more patients in the robotic surgery group compared to the laparoscopic group who received preoperative chemotherapy. This is likely related to changes in practice and guidelines over time and the concurrent increase in the utilization of the robot. Despite these center level differences, we found that in our cohort the rates of conversion to open and morbidity were comparable to existing studies, and believe these cases further add to the literature supporting the safety of this approach in select patients.

Our data highlight several potential benefits of the robotic compared to the laparoscopic and open approach in this patient population. We found that robotic cases had a lower rate of conversion to open and shorter median LOS than surgeries performed laparoscopically. Prior studies utilizing the NSQIP database have shown that compared to laparoscopic hepatectomies, those performed robotically also had a lower rate of conversion to open, and that an unplanned conversion to open led to a longer LOS and increased risk of 30-day mortality [11–12]. Factors contributing to increased rates of conversion to open could be related to certain technical limitations of laparoscopic surgery including lack of three-dimensional visualization and wristed instruments making fine dissection and control of intraoperative complications, such as bleeding, more difficult.

Cost and widespread feasibility are important topics to consider when discussing the utilization of the robotic platform. Although no study thus far has compared the costs of a robotic to laparoscopic approach in simultaneous CRC and CRLM resections, multiple reports have shown that total hospital costs are comparable, and in some cases decreased, for robotic compared to open liver surgery [2,13–14]. As more surgeons and centers expand their use of the robotic platform, future research on cost comparisons between the two MIS approaches in simultaneous resections are warranted.

This study is not without limitations. ACS-NSQIP is a national, standardized, multi-institutional database that focuses on the quality of surgical care but does not include hospital or surgeon specific variables. MILS is more likely to be performed at highly

specialized centers, but due to limitations of the database, the authors cannot definitively comment on this. Despite utilizing a large national database, the number of patients who underwent a robotic simultaneous resection is still low. Lastly, patients were identified separately from either the hepatectomy or colectomy/proctectomy targeted files. As a result, information on procedure risk is limited to either the colorectal or hepatic procedure but not available for both.

The utilization of MIS approaches may mitigate some of the morbidity associated with simultaneous CRC and CRLM resections. As MILS becomes more common, patients may increasingly be offered a robotic approach to simultaneous resections. Data presented in this report suggests that robotic simultaneous resections can be performed without added procedure-specific risks such as ileus, anastomotic leak, liver failure, or bile leak. This information adds evidence to the growing body of literature supporting the use of the robotic platform in increasingly complex procedures and highlights the potential benefits over a laparoscopic approach such as lower rates of conversion and decreased LOS in simultaneous CRC and CRLM resections.

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**TABLE 1.**

30-Day Procedure-Specific Postoperative Complications from Procedure-Targeted NSQIP Files for Simultaneous Resections

Outcome (%)	Colectomy/proctectomy-targeted NSQIP files			Hepatectomy-targeted NSQIP files			<i>p</i> (robotic vs lap)
	Open	Robotic	Lap	Open	Robotic	Lap	
Ileus <sup>a</sup>	124 (24.5)	7 (12.3)	27 (19.0)	-	-	-	0.254
Anastomotic leak <sup>a</sup>	20 (4.0)	3 (5.3)	6 (4.2)	-	-	-	0.750
Postop liver failure <sup>b</sup>	-	-	-	44 (5.1)	0 (0)	2 (1.6)	0.999
Postop bile leak <sup>b</sup>	-	-	-	48 (5.5)	0 (0)	3 (2.4)	0.999
Hepatic invasive procedure <sup>b</sup>	-	-	-	129 (15.0)	0 (0)	18 (14.5)	0.075

<sup>a</sup>Colectomy/proctectomy-specific outcomes available for patients with colectomy/proctectomy resection listed as a primary procedure in the NSQIP colectomy/proctectomy-targeted files only (n= 41%).

<sup>b</sup>Hepatectomy-specific outcomes available for patients with hepatic resection listed as a primary procedure in the NSQIP hepatectomy-targeted files only (n=59%).

Abbreviations: NSQIP, National Surgical Quality Improvement Program; Lap, laparoscopic