Comparative Effectiveness of Minimally Invasive Surgery and Conventional Approaches for Major or Challenging Hepatectomy

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BACKGROUND: The benefits of minimally invasive surgery (MIS) for low-risk or minor liver resection are well established. There is growing interest in MIS for major hepatectomy (MH) and other challenging resections, but there remain unanswered questions of safety that prevent broad adoption of this technique.

STUDY DESIGN: We conducted a retrospective cohort study of patients undergoing hepatectomy at 65 hospitals participating in the NSQIP Hepatopancreatobiliary Collaborative in 2014. We assessed serious morbidity or mortality (SMM; including organ/space infection and organ failure). Secondary outcomes included transfusion, bile leak, liver failure, reoperation or intervention, and 30-day readmission. We also measured factors considered to make resection more challenging (ie large tumors, cirrhosis, $\geq$3 concurrent resections, previous neoadjuvant chemotherapy, and morbid obesity).

RESULTS: There were 2,819 patients who underwent hepatectomy (aged 58 $\pm$ 14 years; 53% female; 25% had MIS). After adjusting for clinical and operative factors, the odds of SMM (odds ratio [OR] = 0.57; 95% CI 0.34 to 0.96; p = 0.03) and reoperation or intervention (OR = 0.52; 95% CI 0.29 to 0.93; p = 0.03) were significantly lower for patients undergoing MIS compared with open. In the MH group (n = 1,015 [13% MIS]), there was no difference in the odds of SMM after MIS (OR = 0.37; 95% CI 0.13 to 1.11; p = 0.08); however, minimally invasive MH met criteria for noninferiority. There were no differences in liver-specific complications or readmission between the groups. Odds of SMM were significantly lower after MIS among patients who had received neoadjuvant chemotherapy (OR = 0.33; 95% CI 0.15 to 0.70; p = 0.004).

CONCLUSIONS: In this large study of minimally invasive MH, we found safety outcomes that are equivalent or superior to conventional open surgery. Although the decision to offer MIS might be influenced by factors not included in this evaluation (eg surgeon experience and other patient factors), these findings support its current use in MH. (J Am Coll Surg 2017;224:851–861.

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Laparoscopy has well-established benefits compared with the conventional, open approach to abdominal surgery, including reduced pain, fewer wound complications, and shorter hospital stays.[1-3] As surgical resection for benign and malignant tumors of the liver has become safer and more common, so has the use of minimally invasive surgery (MIS) in liver resection.[4,5] Numerous studies support the use of MIS in liver resection, reporting less intraoperative blood loss, lower rates of bile leak, and fewer complications.[6-12] Data to support MIS in hepatectomy, however, are derived predominantly from studies of patients undergoing nonanatomic or minor resections of the liver (2 or fewer contiguous Couinaud segments),

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Abbreviations and Acronyms
HPB = hepatopancreatobiliary
MH = major hepatectomy
MIS = minimally invasive surgery
OR = odds ratio
SMM = serious morbidity and mortality

and most studies of MIS have not included high-risk resections.[13-16] According to the recent Second International Consensus on Laparoscopic Liver Resection, minimally invasive minor liver resection is now considered standard of care, but major hepatectomy (MH) (3 or more Couinaud segments) performed via MIS remains an innovative procedure.[17,18] As surgeons gain more experience with MIS techniques, there is growing interest in applying MIS in major liver resections.[19-22] The comparative effectiveness, including oncologic, safety, and cost outcomes of MIS in major hepatectomy, however, has not been established.

Prevention and control of substantial hemorrhage remains the most important intraoperative goal during MH, which can sometimes be challenging in MIS.[19] A primary reason for the choice of open approach rather than MIS is the perceived difficulty of resection.[23,24] A number of known technical, anatomic, and patient factors contribute to the difficulty of resection, including tumor location (particularly right-posterior lesions), large tumor size and extent of resection, proximity to major vessels, underlying liver function, and parenchymal texture.[25,26] The fibrosis and resulting portal hypertension of cirrhosis increases the risk of hemorrhage during parenchymal transection, and there is a paucity of data on the safety of minimally invasive hepatectomy in patients with cirrhosis.[27,28] Similarly, the friable and steatotic liver parenchyma that results from chemotherapy or obesity can make hemostasis more difficult and associated with adverse outcomes.[29-32] Patient habitus can also add to the difficulty of liver resection, although this has not been studied extensively. Liver resection in patients with morbid obesity requires considerably longer operative times, which might be due to difficulty of exposure and fatty infiltration of the liver parenchyma.[33] Although these patient factors influence the choice of surgical approach in liver resection, it is unknown whether MIS resection under challenging conditions is associated with worse outcomes. In this study, we aimed to measure the comparative effectiveness of MIS approaches to hepatectomy among the less well-studied groups of MH and patients with features of a challenging resection.

The NSQIP was developed by the American College of Surgeons for the purposes of measuring surgical outcomes, improving quality and safety of surgical care, and providing validated calculations of surgical risk.[34,35] Procedure-targeted modules within NSQIP allow hospitals to collect organ-specific data on more than 30 high-risk procedures within 9 subspecialty areas.[36] Beginning in 2014, NSQIP formed the hepatopancreatobiliary (HPB) collaborative and began collecting data on patient comorbidities, surgical factors, and 30-day adverse events specifically related to liver resection. This data source presents an opportunity to perform large-scale evaluation of outcomes after major or challenging hepatectomy. By leveraging the NSQIP HPB collaborative procedure-targeted data, we aimed to measure serious morbidity and mortality, as well as liver-related outcomes after MIS and open surgery among patients undergoing liver resection. We hypothesized that the MIS approach to both major and challenging hepatectomies among trained surgeons is as safe as the standard open approach.

METHODS

Cohort selection

We performed a retrospective analysis of all adult patients undergoing elective hepatectomy at 65 high-volume medical centers participating in the NSQIP HPB Collaborative in 2014. All patients included in the HPB collaborative dataset were linked to the NSQIP Participant Use Data File, which includes preoperative laboratory, comorbidity, and demographic data, as well as 30-day in-hospital and post-discharge adverse events. To exclusively capture liver resection cases, we excluded patients who required biliary reconstruction, which involves bowel anastomosis. We identified and reported all cases that had a concomitant colon resection because these cases might have a higher risk of early postoperative complications. Demographic and historical data were obtained on patients before surgery, including laboratory values (eg hepatic panel), medical comorbidities (eg diabetes), and other conditions existing at the time of surgery, including infection or sepsis. After surgery, patients were followed for 30 days for complications, reoperation or intervention, readmission, and death. Due to the deidentified nature of the data, this research was not considered human subjects research and did not require approval by the University of Washington's Human Subjects Division IRB.

Comparison groups

We report outcomes from all hepatectomies, MHs (resection of 3 or more consecutive Couinaud segments, CPT