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Minimally invasive hepatectomy conversions: an analysis of risk factors and outcomes

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Abstract

Background: Surgical approach may influence morbidity following hepatectomy. This study sought to compare outcomes in minimally invasive surgery (MIS), conversion from MIS to open, and planned open hepatectomy patients and analyze factors leading to conversion.

Methods: The 2014 National Surgical Quality Improvement Program dataset was queried for patients undergoing hepatectomy. Patients were divided into three cohorts: MIS, open, or conversion. Propensity matching was performed to compare MIS vs. conversion (3:1) and open vs. conversion (8:1). The logistic regression model was used to identify odds ratios for conversion.

Results: Patients undergoing conversion had a higher transfusion rate (26% vs. 9%, $p < 0.001$), longer length of stay (5 vs. 3 days, $p < 0.001$), and higher morbidity (38% vs. 18%, $p < 0.001$) than MIS patients. Patients who underwent conversion had similar short-term outcomes to those who had planned open procedures. Independent predictors of conversion included hypertension (OR 1.91; 95% CI 1.12–3.26) and right lobectomy (OR 20.23; 95% CI 3.74–109.35).

Conclusion: Patients with hypertension and those undergoing right lobectomy had a higher risk of conversion to open procedure. Conversion resulted in higher morbidity and longer length of stay compared to MIS patients, but outcomes were similar to planned open procedures.

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Introduction

Laparoscopic surgery has become the preferred approach for a variety of abdominal procedures. Technical advancements like laparoscopy in liver resection (LR) have allowed broadened indications for LR to include patients with more extensive underlying liver disease.[1,2] Increasingly, centers are reporting large laparoscopic series of major and minor hepatectomies.[3]

Studies that have compared outcomes of laparoscopic versus open LR have reported laparoscopy to be either non-inferior or superior to an open approach. In patients with oncologic disease, margin status and recurrence rates are similar.[4–6] Laparoscopic LR consistently shows less blood loss and a shorter length of stay than open LR, but morbidity and mortality is either similar, or favors laparoscopy.[4–9] Yet despite the breadth of retrospective reviews on the topic, the level of evidence remains limited due to the absence of randomized controlled trials. Many of the aforementioned series suffer from selection bias given the lack of standardization in care. As an example, adherence to Enhanced Recovery After Surgery (ERAS) protocols may vary between LR surgical approaches and influence outcomes.[10] The potential benefit of laparoscopic LR is thought to be from the lack of a large incision.[11] As such, one may deduce that the advantage of a laparoscopic approach would be lost if the procedure undergoes conversion to an open hepatectomy. Several small series have explored the effect of conversion on liver resection outcomes, but a large population has not been analyzed.

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Blood loss is the most common reason for laparoscopic conversion to open liver resection, followed by failure to progress.[11–13] It is unclear whether blood loss is significantly higher in conversion than open LR, or if such a difference in blood loss is associated with worse postoperative outcomes. Such questions regarding conversion, blood loss, and postoperative outcomes have implications for intraoperative management of laparoscopic LR.[14] This study sought to determine the clinical and demographic factors predicting conversion from laparoscopic to open hepatectomy. Furthermore, propensity-matched comparisons of patients undergoing MIS, open, or converted liver resections would be performed to identify differences in 30-day morbidity and mortality. It is hypothesized that conversion may sacrifice the initial advantage of laparoscopy, but results in no additional detriment compared to planned open liver resection.

Methods

Patient selection

Patients undergoing liver resection between January 1, 2014 and December 31, 2014 at 92 hospitals participating in the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) Procedure Targeted Hepatectomy module were included in this study. This module provides additional liver-specific variables when merged with the existing 2014 ACS NSQIP data.[15] The dataset includes a variable for hepatectomy surgical approach. Patients undergoing hepatectomy by laparoscopic or open approaches were selected, including unplanned conversions from laparoscopic to open. Procedures listed as "hybrid," "laparoscopic with open assist," "robotic with open assist," or "other" were excluded. The ACS NSQIP database provides prospectively collected data including patient demographics, disease characteristics, intraoperative details, and postoperative outcomes within 30 days of surgery. Appropriate approval was obtained from the Medical College of Wisconsin Institutional Review Board.

Data collected for each patient included demographics, comorbidities, clinicopathologic characteristics and values, intraoperative details, and short-term postoperative outcomes. Specific variables identified from the database can be found in Tables 1 and 2. Short-term outcomes measured within 30 days of surgery included the need for invasive postoperative intervention, reoperation, length of stay (LOS), morbidity, readmission, and mortality. Morbidity was defined by the presence of any of the following standard NSQIP postoperative complications: bleeding requiring transfusion, liver failure, bile leak, surgical site infection, wound dehiscence, pneumonia, reintubation, pulmonary embolism, remaining on a ventilator for >48 h, acute renal failure, urinary tract infection (UTI), stroke, cardiac arrest, myocardial infarction, deep vein thrombosis requiring therapy, sepsis, or septic shock. Notably, bleeding requiring transfusion was defined as at least one unit of packed or whole red blood cells given from the surgical start time up to and including 72 h postoperatively. The use of these variables to define morbidity has been used in previously published work regarding liver resection outcomes.[16]

For data analysis, patients were stratified by surgical approach into one of three groups: MIS, conversion, or open. MIS patients underwent either laparoscopic or robotic hepatectomy without conversion, and open patients were planned open procedures (not conversions).

Statistical analysis

Continuous variables were described as medians and interquartile ranges (IQR), while categorical variables were described as total numbers and proportions. Univariate cohort comparisons were analyzed using the Pearson chi-squared or Kruskal–Wallis equality-of-populations rank test where appropriate.

Propensity scoring and matching was performed to minimize selection bias in operative approach due to confounding effects of patient demographics, comorbidities, and preoperative disease status. For the comparison of MIS and conversion patients, 3:1 propensity score matching was applied to 541 patients; 255 MIS and 112 conversion patients were selected. As shown in Table 3, a logistic model was fitted to obtain propensity scores for conversion, in which age, diabetes, gender, hypertension, operative time, resection type, weight loss, and BMI were considered. The significant interaction between operative time and resection type was also included in the model (Table 3). The greedy algorithm attempted to match each conversion patient to 3 MIS patients with the closest propensity score. Matches were required to have a difference of propensity score less than the threshold 0.05. Not every conversion patients had three MIS patients meeting the score threshold, so the resulting ratio was less than 3:1. The well-balanced groups compared in Table 1 are the result of this propensity score matching model.

For the comparison of open and conversion patients, an 8:1 propensity score matching was applied to 2422 patients; 920 open and 115 conversion patients were selected. As shown in Table 4, a separate logistic model was fitted to obtain propensity scores for conversion. Again, age, BMI, type of resection, diabetes, hypertension, operative time, and gender were considered, and the significant interaction between BMI and hypertension was included in the model. As with the matching process utilized for the comparison of MIS and conversion patients, a greedy algorithm was applied for selection of the open versus conversion comparison, resulting in the well-matched groups seen in Table 2.

The logistic model used in the propensity scoring of the MIS and conversion patients was used to identify independent risk factors for conversion in all patients who were intended to have MIS (Table 3). Variables with significant odds ratios for conversion on univariate analysis were included in the final multivariate model. Additionally, age, gender, and BMI were forced into the model due to concerns for interaction with the

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